Nurserymen's Meeting
Orono Forest Station
June 24-27, 1985

Ontario
Ministry of Natural Resources
Hon. Vincent G. Kerrio
Minister
Mary Mogford
Deputy Minister

ISSN 0824-8931

© 1986, Queen's Printer for Ontario

Printed in Ontario, Canada

Current publications of the Ontario Ministry of Natural Resources, and price lists, are obtainable through the Ministry of Natural Resources Public Information Centre, Room 1640, Whitney Block, 99 Wellesley Street West, Toronto, Ontario M7A 1W3 (personal shopping and mail orders).

And:

Personal shopping: Ontario Government Bookstore, Main Floor, 880 Bay Street, Toronto.

Mail Orders: MGS Publications Services Section, 5th Floor, 880 Bay Street, Toronto, Ontario M7A 1N8. Telephone 965-6015. Toll free long distance 1-800 268-7540, in Area Code 807 dial 0-Zenith 67200.

Cheques or money orders should be made payable to the Treasurer of Ontario, and payment must accompany order.

FOREWORD

I would like to take this opportunity to express my thanks to all the people who made this conference a success, especially those on the organizing committee - Dave Moore, Lloyd Pfeffer and Don Boufford.

Glenn McLeod
Orono Provincial
Forest Station

CONTENTS

CONTROLLING SEEDLING GROWTH WITH FERTILIZER TOP DRESSING
W.R. Bunting 1
BLACK SPRUCE SEEDLING ESTABLISHMENT: DIAGNOSIS AND AMELIORATION OF A SITE-SPECIFIC NUTRIENT DEFICIENCY
A. Munson and V.R. Timmer 18
ROOT PRUNING AND WRENCHING
A.J. Campbell 26
A NEW LOOK AT SEEDBED MULCHING
G.D. Racey 32
THE POTENTIAL FOR STEROL-INHIBITING COMPOUNDS IN FOREST SEEDLING PRODUCTION
G. Hofstra 38
HAND-HELD DATA ENTRY DEVICES FOR FORESTRY
D.C. MacIver 46
BRITISH COLUMBIA NURSERY PRODUCTION
C. Kooistra 54
NEWFOUNDLAND NURSERY PRODUCTION
T. McDonough 66
CONTAINERIZED JACK PINE GROWTH IS REDUCED ON CERTAIN PEAT TYPES
R.S. Folk and V.R. Timmer 73
HERBICIDE USE AND MONITORING
C.G. Waywell 79
RED PINE STOCK-TYPE TESTING PROGRAM
G.D. Racey 84
A COMPARISON BETWEEN RED PINE SEEDLINGS AND TRANSPLANTS FIVE YEARS AFTER OUTPLANTING
J.M. Paterson 87
CONDITIONS OF RED OAK NURSERY STOCK AS RELATED TO OUTPLANTING
G. Stroempl 90
GREENHOUSE TRANSPLANTS - LANNEN'S PAPERPOTS
S.T. Griffiths 97
TREE IMPROVEMENT
J.V. Hood 102

Appendix 1 - Agenda 107
Appendix 2 - Attendance 108

CONTROLLING SEEDLING GROWTH WITH FERTILIZER TOP DRESSINGS

W.R. Bunting
Nu-Tech Services
37 David's Crescent
Box 424
Orono, Ontario
L0B 1M0

Introduction

One of the more difficult tasks facing nursery staff, in the production of forest tree seedlings, is the production of a product of uniform size, year after year. To assist Ontario government nurserymen, the Ontario Ministry of Natural Resources has developed a plant and soil sampling programme which produces recommendations, for soil amendments (to produce optimum growing conditions) and fertilizer top dressing applications, based on seedling size, to standardize growth.

While the programme is most helpful to nurserymen, it is still a fact that Ontario nurseries do produce seedlings that are quite often either larger or smaller than were originally planned.

It has been suggested (Bunting, 1983) that growth predictions, made in the fall of the current year and estimating the next season's final Root Collar Diameter (RCD), be used to interimly assess whether the seedlings are developing as desired or whether modifications to cultural practices are required to produce seedlings of a planned size. The author feels that this forecasting technique is now fully operational, and a manual describing this procedure has been written and is presently in the process of being produced.

The problem that must be addressed next is, if the forecast predicts that the seedlings are not developing as planned, how do you go about increasing or decreasing growth to get the seedlings to meet the original size specification.

There are several means that might be used to attempt to slow down or speed up growth. I feel the first and most obvious is varying the amount of fertilizer applied to the crop as top dressing. Secondly, monitoring soil moisture and maintaining it at optimum levels, to encourage growth, or at higher tensions to restrict growth. There is one problem associated with controlling growth through the manipulation of soil moisture and that is, what do you do in a year that it rains regularly and soil moisture is not limiting factor, as at Swastika in 1984? Thirdly, root pruning, or root pruning and root wrenching may be used as is done by Alf Campbell of Kemptville nursery and was recommended by Bunting (1984a).

At Orono, to get a handle on how much we might be able to manipulate growth by using fertilizer, we started a series of trials beginning in the spring of 1979. To date four trials have been completed. One has been reported by Bunting (1984b) and the rest will be covered in this paper.

In dealing with fertilizer, as a method of controlling growth, it is a fact that soil fertility is pretty well set for any given rotation. In other words, over the rotation period, the pH and organic carbon are near optimum and levels of the macro nutrients cannot be changed. But low levels of macro nutrients may be compensated for by adding them as part of the top dressing programme. At Orono, where most of the seedbed land approaches optimum levels, which are: pH 6.0 - 6.5, organic carbon 3%, phosphorus 30 mg/100g, potassium 0.30meq/100g and magnesium 0.50meq/100g. It is obvious because of this, that if we are to influence growth, then it has to be done through the manipulation of nitrogen top dressings.

On the other nurseries where soil conditions may not be near optimum levels, growth may be limited by low soil phosphorus, potassium, magnesium, etc. These elements may have to be incorporated into the top dressing programme to get a growth response.

Trial No. 1, 1979

The trial was laid out in a random plot design with four replications. Sample plots were located in each treatment and replication, at points of uniform density, and 25 seedlings in the case of the pines and 35 in the case of white spruce were systematically chosen and tagged to be measured

for RCD over the summer. The RCD measurements were made at two weekly intervals to ascertain the rate of growth from May to September.

In this trial, it was decided to apply the varying fertilizer rates to rising 3+0 red pine (Pinus resinosa Ait.), white pine (Pinus strobus L.) and white spruce (Picea glauca [Moench] Voss). The rates of application were 0.5N (on half of the normal application of nitrogen), 1N (normal nitrogen) and 2N (twice normal nitrogen). We did not have a true control in the form of a 0N, however, we expected to use the 1N treatment as the control and compare differences in other treatments to it.

Normal nitrogen (1N) for 3+0 red pine and white spruce, at this time, was 560 kg/ha of ammonium sulphate applied in five monthly applications of 112 kg/ha from May to September. For white pine, the normal rate was 896 kg/ha of ammonium sulphate applied in eight applications of 112 kg/ha at approximately three week intervals from May to September.

Results: The growth rates (slopes) of the growth curves (mm/day) are shown in Table 1. There were no significant differences in the slopes between the treatments for any of the species. Figure 1 illustrates this.

While these negative results were surprising, it would seem that the seedling growth rates were set for the 3+0 year, after having received 1N rate of applications during the 1+0 and 2+0 seasons. The fertility regimes in the 3+0 season alone were not able to alter the growth rate.

Trial No. 2, 1980

The trial was laid out in a four replicated random plot design. Sample plots were located in each treatment and replication, at points of uniform density (thinning to uniform density was carried out if required). Twenty-five seedlings in the case of pines and 35 of white spruce were systematically chosen and tagged to be measured for RCD over the summer and into the fall until RCD growth ceased (about September 15).

This trial was similar to the first, except it received nitrogen during the 2+0 year. The following treatments were chosen: 0N (control, no nitrogen), .25N (one quarter normal nitrogen), .5N (half normal nitrogen), 1N (normal nitrogen) and 2N (twice normal nitrogen).

Normal nitrogen application for 2+0 red pine and white spruce was five times of ammonium sulphate @ 84 kg/ha applied once in May, June, July, August and October with a 112 kg/ha of 13-52-0 in September. For white pine, normal nitrogen was applied nine times @ 84 kg/ha at approximately three week intervals from May to October. The September application was, once again, 112 kg/ha of 13-52-0.

Results: The growth rates (slopes of the RCD growth curves) did not show any significant differences between treatments (Table 2). This came as quite a surprise as we had expected real differences, at least, between 0N and 1N. While differences were not significant there were increases in RCD of from 5 to 10% for white pine and white spruce and 15% for red pine. Figure 2 illustrates these results.

Once again, it appeared that after having received 1N treatment in the 1+0 year, the 2+0 growth rates were set and varying nitrogen amounts during the second season affected RCD growth only marginally, if at all.

3+0 Results: During the 3+0 growing season (the second season that the fertility regimes were imposed) the white pine growth curves did exhibit significant differences in growth between treatments (Figure 3), however there were no significant differences in the red pine (Table 3). In comparing the fertilizer treatments with the 0N (Control) treatment in white pine, there were increases in growth ranging from 70 to 320%. In red pine, while these differences were not significant, there appeared to be increases from 20 to 30%.

These data would seem to indicate that if you intend to alter the slope of the RCD white pine growth curves, by manipulating the nitrogen top dressing applications, then it is necessary to do so over the 2+0 and 3+0 growing seasons. The fertility regimes had less effect on the growth of red pine.

While we were not able to include white spruce in this 3+0 trial, past experience with this species has shown that white spruce to be more sensitive to variations in top dressings than red pine and white pine (Bunting, 1983), and it is our opinion, that had we been able to test it here, it would have exhibited significant differences in growth.

Trial No. 3, 1982

In this trial, it was decided to begin superimposing the various top dressing rates beginning in the 1+0 year. Once again white pine, red pine and white spruce were chosen as the species to be treated. The trials were laid out in a random plot design with four replications in the case of white and red pine and six replications for white spruce. Since the white spruce was doubling as a trial for the University of Guelph's investigation of multiple leadering, we decided to use, 0N (control), .5N (half normal nitrogen), 1N (normal nitrogen) and 2N (twice normal nitrogen), as treatments.

First Year: Normal top dressings for 1+0 red pine and white spruce were three monthly applications of ammonium sulphate at 56 kg/ha applied about the beginning of mid-June followed by a mid-September application of 13-52-0 at 112 kg/ha. For white pine, a normal application consisted of six applications of ammonium sulphate at 56 kg/ha beginning the first of June and applied at approximately three weekly intervals until October, with the September application being made with 13-52-0 at 112 kg/ha.

Results: No growth curves were developed for the 1+0 year since they are very difficult to construct due to a) the very small diameters of this age class, and the extremely small increments from week to week make it almost impossible to get meaningful measurements with the instruments available. b) The stems of the seedlings, for most of the season, are very soft, once again making it very difficult to get meaningful measurements because of the danger of squashing the stem. The stock was sampled in the fall of 1982, and measured for RCD, HT, RAI, TDW and T/R. The results of these measurements were reported by Bunting in the Proceedings of the Nurserymen's Meeting, Kemptville, June 1983 (Table VIII-4). Table 4, in this report, shows the results of the RCD measurements.

Visual observation of the plots at the end of the first season did not indicate any differences in colour or in size of the seedlings. However, from these data there were significant increases in RCD for white pine and white spruce. RCD development was optimized for white pine at the normal rate of top dressing and for white spruce at one half of the normal rate. Red pine RCD development was unaffected by the amount of top dressing applied.

Second Year - 1983: Normal top dressings for the rising 2+0 red pine and white spruce were four applications of ammonium sulphate, at 84 kg/ha, beginning in mid-May and continuing to mid-August, followed by a mid-September application of 13-52-0 at 112 kg/ha. For white pine, a normal application consisted of eight top dressings of ammonium sulphate, at 84 kg/ha, beginning in mid-May and continuing at approximately three week intervals until October, plus a mid-September application of 13-52-0 at 112 kg/ha. All fertilizer regimes received two operational applications of potassium sulphate at 60 kg/ha (one in May and one in July).

Results: There were highly significant differences between the treatment growth curves for all three species (Table 5). To maximize the growth rate, the normal treatment produced the best growth for all species. A 21% increase for white pine, a 25% increase for red pine and a 35% increase for white spruce, when this treatment is compared to control.

Increasing the fertilizer rate to 2N produced significantly poorer growth for white pine and white spruce and while not significant, also for red pine. Apparently, the 2N rate of nitrogen top dressings place all three species on the back side of the growth curve.

Figure 4 shows the white spruce growth curves which are representative of these treatments.

Figure 5 shows the average daily growth rate (mm/day), achieved by the three species when plotted over the amount of elemental nitrogen applied in kg/ha. It can be seen from these data that the white spruce RCD growth rate is the most sensitive to additions of nitrogen,

followed by white pine and then red pine. This Figure illustrates once again, that the growth rate is maximized for all three species at the normal rate of application. The data on which this Figure is based may be found in Appendix 1.

Third Year - 1984: Normal top dressings in the 3+0 year were the same as for the 2+0 year except that the amount of ammonium sulphate, per application, was increased to 112 kg/ha. Also two potassium sulphate applications were made (one in May and one in July). The mid-September application of 13-52-0 remained at 112 kg/ha.

As the seedlings were developing over the season, colour and size differences could be observed in the white spruce. The 0N and .5N seedlings appearing a yellower green and also shorter than the 1N and 2N treatments. Near the end of the season, while no real difference could be seen in the height of red pine or white pine, a higher proportion of the 2N white pine produced as lammas growth and tallest of the 2N red pine began to show signs of potassium deficiency, a yellowing of the needles starting at the tip and working toward the base. This latter observation may have been caused by the extra nitrogen being applied in the 2N treatment, displacing potassium from the soil colloidal complex.

Results: Much to our surprise, only the white pine growth curves proved to have significant differences between treatments (Table 6). Figure 6 shows the growth curves for 3+0 white spruce which are representative of this age class.

Figure 7 shows the average daily growth rate achieved by the three species. From these data the white pine growth rate, as in the 2+0 year, reached its maximum in the 1N treatment, however, since the 2N growth rate is only slightly less, one wonders if a 1.5N regime might not have produced better growth. The data on which this Figure is based can be found in Appendix 1.

While not significant, red pine growth rates seemed to be indifferent to fertilizer regimes, but were maximized at the 1N levels. Once again, while not significant, the white spruce growth rate reached its maximum in the 2N regime. It is impossible to tell what rate of growth

white spruce might have reached since fertility regimes were not high enough to place it on the back side of the growth curve. This same result was reported in the Proceedings of the Nurserymen's Meeting, Kemptville, 1983, from another trial (Bunting 1983, Figure VIII-8) where the largest 3+0 white spruce were produced by a 2N treatment.

Discussion

The Orono top dressing programme was developed to maximize the growth of the seedlings. It is nice to have confirmation that for white pine this is still the case. For white spruce, a larger seedling could still be produced in the 3+0 year by increasing the rate of top dressing. Whether this is desirable or not is questionable, since Orono's 3+0 white spruce is already large to very large, according to the Ontario grading system. Certainly the red pine top dressing programme should be assessed again in view of the results of these tests.

I feel that these data show that there are a number of growth paths along which seedlings may be grown by manipulation of the nitrogen top dressing programme. I further feel, that nursery personnel could use this technique along with growth prediction, to assist them in producing seedlings or transplants of a given shipping size.

After all is said and done, the sum of the cultural programmes on a nursery is to produce shippable seedlings or transplants of a size that will survive and grow well after outplanting. In his work at Thunder Bay nursery (McClain, 1982) reported, for white spruce, that increasing levels of nitrogen top dressings were detrimental to both survival and growth after outplanting. We did not find this relationship in a previously published report (Bunting, 1984b), where survival of white spruce, white pine and red pine were not affected by increasing levels of nitrogen, and growth of white spruce, after outplanting, showed a positive response to these increasing levels.

To test this hypothesis, that increasing levels of nitrogen do not affect outplanting survival or growth, all treatments from the three year trial were outplanted in a replicated test, on the Orono nursery, this spring, and an assessment will be made this fall. You will be given an opportunity to see this planting tomorrow. The last time I looked at it (yesterday)

there were no visible differences one could see in survival between treatments. Survival of all species and treatments appear to be 90% plus. The only observable difference at this time is in the white pine, and there the 0N and .5N treatments suffered some foliage death right after planting. This mortality appeared to be similar to the damage reported, by at least Orono and Midhurst nurseries, in stock that was lifted and shipped this spring, during periods of very warm weather.

As far as growth is concerned, the only differences I have been able to see are in the 0N and possibly in the .5N white spruce treatments, where they have been slower to break bud than have the other treatments.

Conclusion:

1. The chances of changing the growth rate in the 3+0 year is very small if normal levels of top dressings have been made in the 1+0 and 2+0 years.

2. If normal nitrogen top dressings are applied in the 1+0 year, the changes that can be made in the 2+0 growth rates are small for all species. If changed fertilizer top dressing regimes are maintained in both the 2+0 and 3+0 seasons, small changes may be made in red pine but large changes may be made in white pine, and, I suspect, in white spruce.

3. By imposing fertilizer top dressings regimes in the 1+0 year and continuing them through the 2+0 and 3+0 years, a large variety of product sizes may be produced for white pine and white spruce. The ability to change the size of the final red pine product by top dressing manipulation is limited.

4. Each species should be treated individually as far as its requirements for nutrients are concerned. All of them reacted differently to the amounts of top dressing fertilizer applied: white spruce being the most sensitive to changes in top dressing rates, followed by white pine which required larger changes to produce equivalent changes in growth rates, and red pine which was the least sensitive of the three.

5. Survival and growth after outplanting were not affected by the various levels of nitrogen top dressings used in these trials.

References

Bunting, W.R. 1983. Seedling growth prediction and growth control. Proceedings of Nurserymen's Meeting, Kemptville, June, 1983. Ontario Ministry of Natural Resources, Kemptville, Ont. p. 34-61.

Bunting, W.R. 1984a. Root pruning and root wrenching. Proceedings of Nurserymen's Meeting, Swastika, 1984. In press.

Bunting, W.R. 1984b. The effect of increasing nitrogen fertilizer rates on seedling growth and post planting survival and growth. Nursery Notes, No. 109, May 1984. Ontario Ministry of Natural Resources. Mimeo 12 p.

McClain, K.M. 1982. Seedbed spacing and nitrogen effects, on nursery growth and post planting performance of white and black spruce. Proceedings of Nurserymen's Meeting, Thunder Bay, June 1982. Ontario Ministry of Natural Resources. p 59-72.

Table 1. Summary of slopes for the 1979 3+0 RCD growth curves

Treatment	White Pine	Red Pine	White Spruce
.5N	0.011195	0.0071404	0.023199
1N	0.012503	0.0085549	0.021881
2N	0.013573	0.0073790	0.025380
	NS	NS	NS

NS - Not significant.

Percentage increase when comparing:			
1N & .5N	11.6%	19.8%	-5.7%
2N & .5N	21.2%	3.3%	9.4%

Table 2. Summary of slopes for the 1980 2+0 RCD growth curves

Treatment	White Pine	Red Pine	White Spruce
0N	0.018212	0.013935	0.01888
.25N	0.016357	0.016727	0.02129
.5N	0.019523	0.016494	0.020187
1N	0.020369	0.016485	0.019945
2N	0.019092	0.016439	0.020860
	NS	NS	NS

NS - Not significant.

Percentage increase when comparing:			
.25N & 0N	-10.2%	20.0%	12.8%
.5N & 0N	7.2%	18.4%	6.9%
1N & 0N	11.8%	18.3%	5.6%
2N & 0N	4.8%	18.0%	10.5%

Table 3. Summary of slopes for the 1981 3+0 RCD growth curves

Treatment	White Pine	Red Pine	White Spruce
0N	0.0028041	0.0050968	NO
.25N	0.0047087	0.0063235	D
.5N	0.0062274	0.0066137	A
1N	0.0087299	0.0060482	T
2N	0.0117410	0.0064687	A
	*	NS	

NS - Not significant
* - Significant at 5% level.

Percentage increase when comparing:		
.25N & 0N	67.9%	24.1%
.5N & 0N	122.1%	29.8%
1N & 0N	211.3%	18.7%
2N & 0N	318.7%	26.9%

Table 4. Summary of 1+0 RCD measurements for 1982

Treatment	White Pine	Red Pine	White Spruce
0N	1.26a	1.07	0.84a
.5N	1.29a	1.08	0.95a
1N	1.42 b	1.10	0.99 b
2N	1.45 b	1.13	0.97 b
	#	NS	*

NS - Not significant
* - Significant at 5% level
# - Significant at 1% level.
Figures followed by the same letter do not vary significantly at the 5% level.

Percentage increase when comparing:			
.5N & 0N	2.3%	1.0%	13.1%
1N & 0N	12.7%	2.8%	17.9%
2N & 0N	15.1%	5.6%	15.5%

Table 5. Summary of slopes for the 1983 2+0 RCD growth curves

Treatment	White Pine	Red Pine	White Spruce
0N	0.01123 b	0.01067 b	0.01277 c
.5N	0.01294a	0.01260a	0.01502 b
1N	0.01358a	0.01331a	0.01729a
2N	0.01130 b	0.01303a	0.01394 bc
	@	@	@

@ - Significant at 0.1% level.
Figures followed by the same number do not vary significantly at the 5% level.

Percentage increase when comparing:			
.5N & 0N	15.2%	18.1%	17.6%
1N & 0N	20.9%	24.7%	35.4%
2N & 0N	0.6%	22.1%	9.2%

Table 6. Summary of slopes for the 1984 3+0 RCD growth curves

Treatment	White Pine	Red Pine	White Spruce
0N	0.00866a	0.01000	0.00962
.5N	0.01137 b	0.00956	0.01271
1N	0.01449 c	0.01098	0.01487
2N	0.01427 c	0.00898	0.01849
	*	NS	NS

NS - Not significant
* - Significant at 5% level
Figures followed by the same letter do not vary significantly at the 5% level.

Percentage increase when comparing:			
.5N & 0N	31.3%	-4.4%	32.1%
1N & 0N	67.3%	9.8%	54.6%
2N & 0N	64.8%	10.2%	92.2%

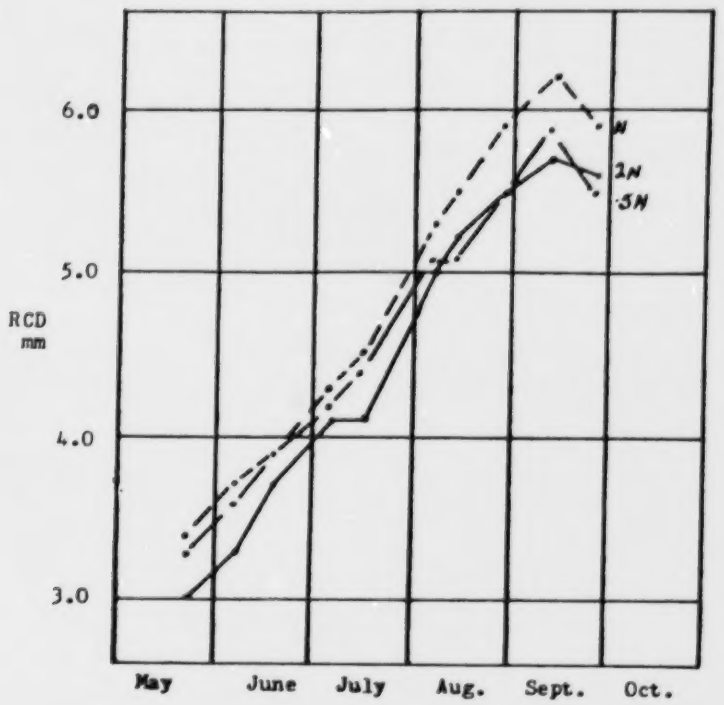

Figure 1. 1979 Fertility trial, white spruce 3+0, comp. H-18

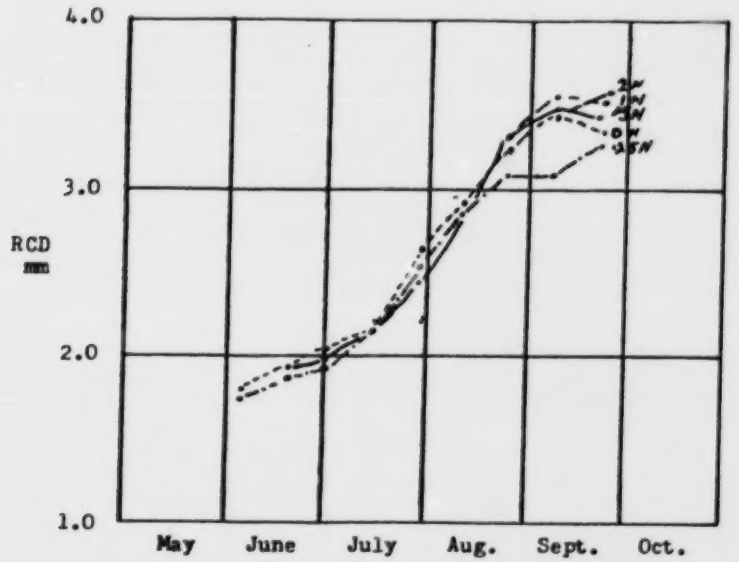

Figure 2. 1980 Fertility trial, white pine 2+0, comp. S-32

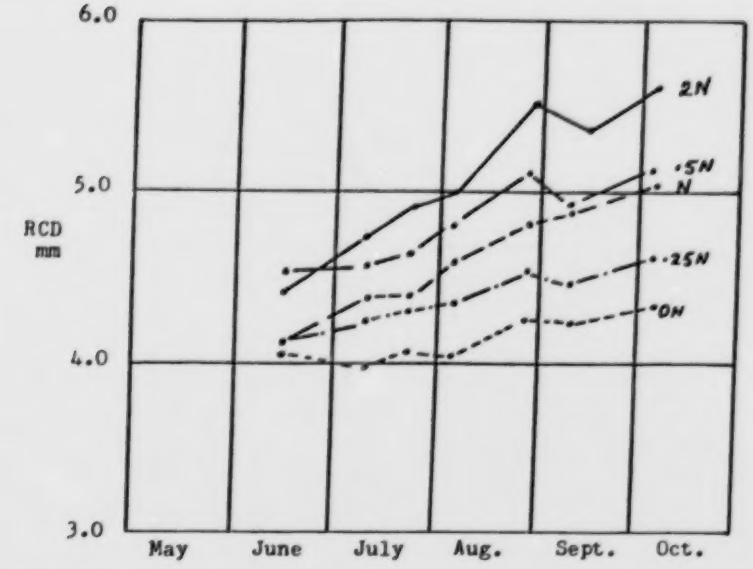

Figure 3. 1981 Fertility trial, white pine 3+0, comp. S-32

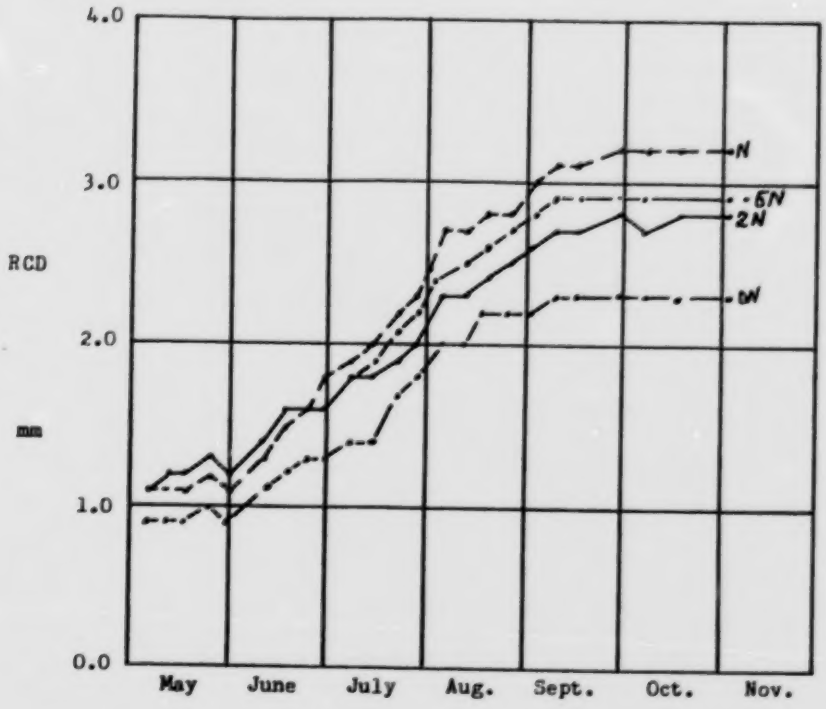

Figure 4. 1983 Fertility trial, white spruce 2+0, comp. S-26

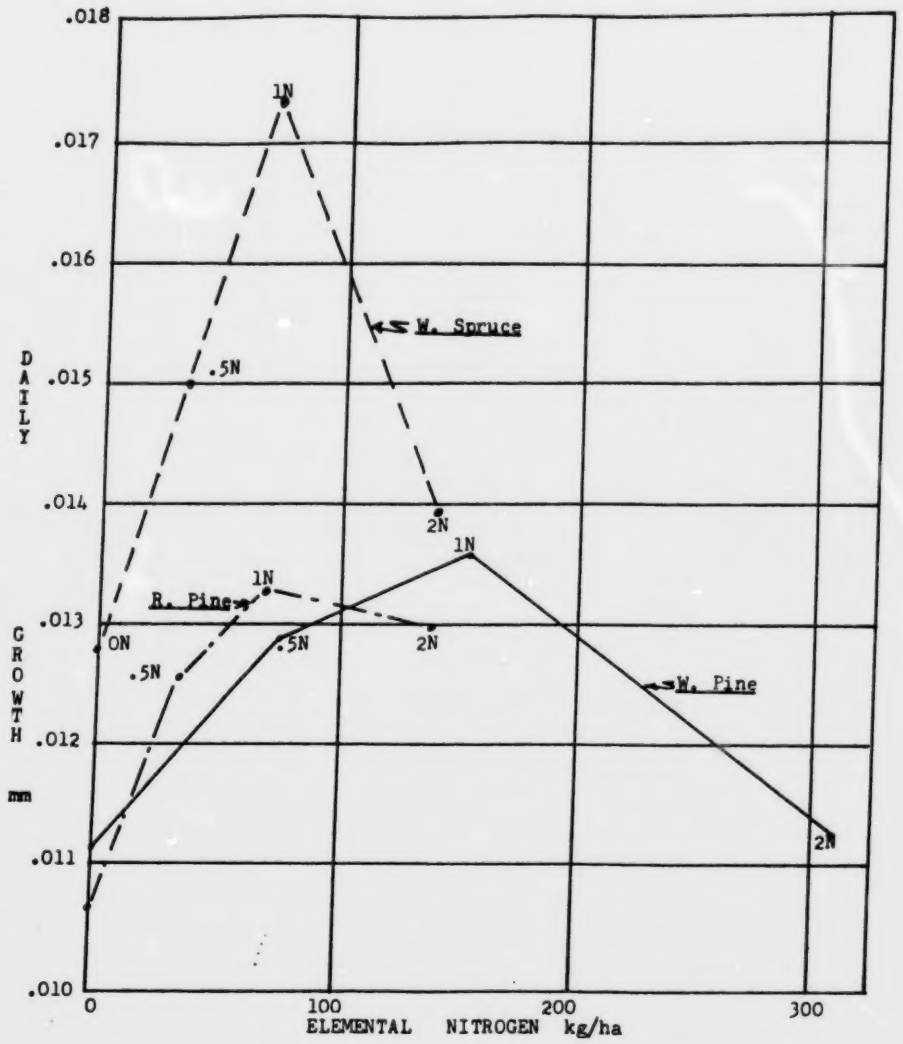

Figure 5. 1983 Fertility trials, 2+0 growth rate in mm/day

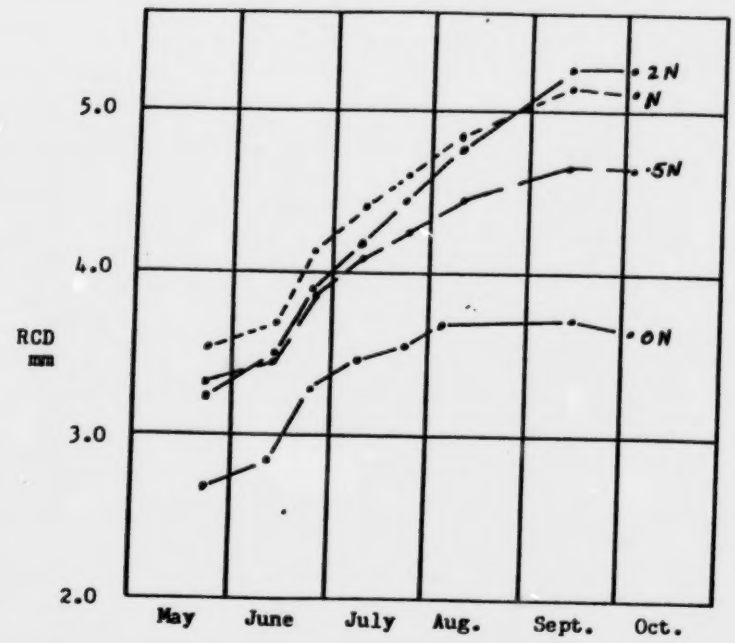

Figure 6. 1983 Fertility trial, white spruce 3+0, comp. S-26

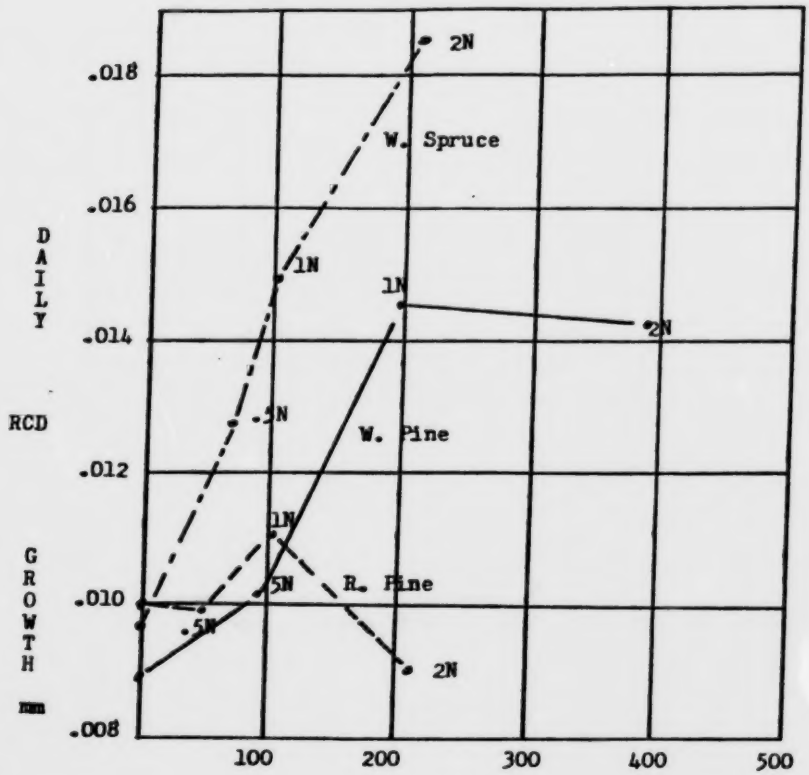

Figure 7. 1984 Fertility trials, 3+0 growth rate in mm/day

APPENDIX 1

Calculation of the total amount of elemental (el.) nitrogen applied in kg/ha.

Trial No. 3

1983 - 2+0 white pine
Normal = 8 applications of $(NH_4)_2SO_4$ @ 84 kg/ha

	N	.5N	2N
No. kg/ha of elemental N = 8 x 84 x .2	= 134.4	67.2	268.8
13-52-0 = 1 app. @ 112 kg/ha = 13 x 1.12	= 14.6	14.6	14.6
Total:	149.0	81.8	283.4

1983 -2+0 red pine & white spruce.
Normal = 4 applications of $(NH_4)_2SO_4$ @ 84 kg/ha

	N	.5N	2N
No. kg/ha of elemental N = 4 x 84 x .2	= 67.2	33.6	134.4
13-52-0 = 1 app. @ 112 kg/ha = 13 x 1.12	= 14.6	14.6	14.6
Total:	81.8	48.2	149.0

Growth rate (mm/day)
by treatment (kg/ha of el.N)

treatment	el.N	w.pine slope	el.N	r.pine slope	w.spruce slope
0N	0	.01123	0	.01067	.01277
.5N	82	.01294	48	.01260	.01502
1N	149	.01358	82	.01331	.01729
2N	283	.01130	149	.01303	.01394

1984 - 3+0 white pine
Normal = 8 applications $(NH_4)_2SO_4$ @ 112 kg/ha

	N	.5N	2N
No. kg/ha of elemental N = 8 x 12 x .2	= 179.2	89.6	358.4
13-52-0 = 1 app. @ 112 = 13 x 1.12 kg/ha	= 14.6	14.6	14.6
Total:	193.8	104.2	373.0

1984 - 3+0 red pine and white spruce
Normal = 4 applications $(NH_4)_2SO_4$ @ 112 kg/ha

	N	.5N	2N
No. kg/ha of elemental N = 4 x 112 x .2	= 89.6	44.8	179.2
13-52-0 = 1 app. @ 112 = 13 x 1.12 kg/ha	= 14.6	14.6	14.6
Total:	104.2	59.4	193.8

Growth rate (mm/day)
by treatment (kg/ha of el.N)

treatment	el.N	w.pine slope	el.N	r.pine slope	w.spruce slope
0N	0	.00866	0	.01000	.00962
.5N	104	.01137	59	.00965	.01271
1N	194	.01449	104	.01098	.01487
2N	373	.01427	194	.00898	.01894

BLACK SPRUCE SEEDLING ESTABLISHMENT: DIAGNOSIS AND AMELIORATION OF A SITE-SPECIFIC NUTRIENT DEFICIENCY

A. Munson and V.R. Timmer
Faculty of Forestry
University of Toronto

Introduction

Foresters have noticed marked growth differences in the early development of containerized black spruce seedlings planted on different site types in the Northern Region Claybelt. Last year we tested this phenomena in a simple greenhouse experiment by growing black spruce container seedlings on intact forest floor substrates collected from typical feathermoss and sphagnum site types in the Claybelt. Over a four-month growing period seedling height, root collar diameter and dry matter production were much greater on the feathermoss compared to the sphagnum substrate (Munson and Timmer 1984). The growth reduction (42% of dry weight) was associated with reduced N uptake of seedlings and a higher C:N ratio of substrates, suggesting lower N availability on the sphagnum-dominated sites. Work reported here confirms this diagnosis, and tests cultural practices which may ameliorate these conditions.

Verification: Field and pot trials

To verify these preliminary greenhouse results, trials were conducted in the field (Kapuskasing District) and in pots at the Glendon nursery. Both trials comprised replicated plantings of container stock on 3 black spruce-dominated operation groups (OG) of the Forest Ecosystem Classification system (Jones et al. 1983): a lowland labrador tea site (OG 11), a lowland alder site (OG 12) and an upland feathermoss type (OG 5). The lowland forest floors consist mainly of sphagnum material over deep organic soils, while the upland substrates are of feathermoss origin overlying moderately well-drained, fine textured mineral soils.

In the spring of 1984, black spruce container seedlings (with paperpots and soil removed) were planted on sample plots established on recent cutover areas which were representative of the three operational groups.

Concurrently, at Glendon, seedlings were planted on intact blocks of forest humus collected from the same field plots. At the end of the season, seedlings from both field and pot experiments showed the same trends in growth performance and nutrient uptake noted in the previous greenhouse trial. Root collar diameter of seedlings on the feathermoss site averaged 24% and 31% greater (field and nursery, respectively) than seedlings on the labrador tea site (Table 1). Dry matter production showed a similar response pattern. Chemical analysis of seedlings indicated that nutrient uptake was least on the labrador tea site and greatest on the feathermoss operational group, N status seemed most variable with site (Table 2).

These outplanting results tend to support our initial observation of distinct differences in nutrient availability among substrates. Comparative foliar analysis of seedlings from each site singled out N as the most limiting nutrient (Figure 1), because of all nutrients assessed, N exhibited the largest proportional difference in concentration and content levels. Interpretations based on size and orientation of N vectors signified that the lowland sites were comparatively more N deficient than the upland feathermoss sites.

Nitrogen fertilization

To confirm the apparent N deficiency on lowland sites, a separate fertilization trial was carried out at the Glendon nursery. Seedlings were planted on intact potted substrates from each of the 3 operational groups. When needles started to become chlorotic in mid season (a typical symptom of N deficiency), ammonium nitrate was applied at a rate of 83 kg N/ha. Fertilization induced a rapid change in foliage colour (to blue-green). By the end of the season average growth and N content were higher than control levels (Table 3), other element concentrations appeared to be diluted by increased growth (Figure 2). Seedling dry weight on fertilized OG 11 and 12 substrates increased 22% and 26% over controls. The small (2%) response on the upland site implied luxury consumption of N, since seedlings appeared to take up extra N which was not translated into growth. The greater responsiveness of seedlings planted on lowland sites confirmed the severe N deficiency on these sites. The incidence and extent of dilution, deficiency and luxury consumption of nutrients are reflected in graphical representations of response patterns in seedling tips (Figure 2). These pot trial responses have to be verified in the field.

Greenhouse production of site-specific seedlings

Fertilization may be one option for ameliorating N deficiency on lowland sites. A second option we are testing is planting seedlings that have been deliberately pre-conditioned for N-deficient sites. Seedlings are "loaded" with N at the production stage in order to build up high N reserves that can be utilized during establishment. The objective is to produce a site-specific seedling for reforestation purposes.

We tested this practice experimentally by raising containerized black spruce in the greenhouse at higher nutrient regimes: at 1, 3 and 5 times recommended N rate (R, 3RN, 5RN), and at 5 times recommended NPK rate (5RNPK). At the end of the greenhouse rotation we noted that growth was similar for seedlings receiving R and 3RN treatments, but those reared at 5RN were slightly smaller. However, growth was markedly reduced by the 5RNPK treatment, probably because of salt toxicity. Plant N concentration increased with higher N regimes (2.33, 2.83, and 3.69% for R, 3RN and 5RN, respectively). The trial demonstrated that similar-sized seedlings with higher N reserves can be raised successfully on an operational basis, simply by supplementing the routine N regime.

The next step was to field test pre-conditioned seedlings on the N-deficient sites. In the spring of 1985, we outplanted a crop of current stock (raised at R, 3RN and 4RN regimes) in the Kapuskasing district and also in pots at Glendon nursery. The field results were confounded by two heavy frosts in June which caused considerable needle browning on recently planted seedlings. A visual assessment of injury found that 3RN- and 4RN-treated trees were more severely affected than R-treated trees (Table 4). Evidently, problems of increased frost susceptibility must be considered in the production and cold hardening of "loaded" seedlings. Other studies, however, have shown that high N applications reduced frost damage and improved field survival of seedlings (Benzian et al. 1974). Results seem to vary with climate and species. Interestingly, we noted almost complete survival in our pot experiment, although the seedlings have not been harvested yet. So far, the pre-conditioned trees appear to exhibit much better growth and vigour than normally reared seedlings.

Conclusions

Results from the greenhouse, field and pot trials have demonstrated reduced availability of N on lowland sites, which adversely affected growth performance. Fertilization with N improved seedling development on the N-deficient substrates in a pot trial. This practice is now being tested on a larger scale in the field. Pre-conditioning seedlings by N loading prior to outplanting is also being conducted to evaluate if growth can be improved on lowland operational groups. We next intend to focus our attention on correlating seedling performance with substrate quality, characterizing the chemistry of substrates by laboratory analyses, and developing and index of N availability in forest floors using incubation techniques.

The degree of N availability on these Claybelt sites seems to critically affect early seedling performance in plantations, which has important implications for future stand development. Obviously, container growers and forest managers should be aware of techniques for manipulating seedling nutrient status at the production and outplanting stage, so that performance can be improved on sites with known N deficiency. We hope to contribute to this knowledge by completing these studies.

References

Benzian, B., R.M. Brown and S.C.R. Freeman. 1974. Effect of late-season top-dressings of N (and K) applied to conifer transplants in the nursery on their survival and growth on British forest sites. Forestry 47: 153-184.

Jones, R.K., G. Pierpoint, G.M. Wickware, J.K. Jeglum, R.W. Arnup and J.M. Bowles. 1983. Field Guide to Forest Ecosystem Classification System for the Claybelt, Site Region 3E. Ontario Ministry of Natural Resources, Toronto, p. 122.

Munson, A. and V.R. Timmer. 1984. Forest floor effects on growth of black spruce container seedlings. In: Nurserymen's Meeting, Kirkland Lake, June 1984. Ontario Ministry of Natural Resources, Toronto. p. 148-152.

Timmer, V.R. and L.D. Morrow. 1984. Predicting fertilizer growth response and nutrient status of jack pine by foliar diagnosis. In: Forest Soils and Treatment Impacts. E.L. Stone (ed.) Proc. 6th North Am. For. Soil Conf. Knoxville. p 335-351.

Table 1. Morphological characteristics of black spruce container seedlings planted on three operational groups

Trial	Operational Group	Diameter (mm)	Seedling Dry Weight (g)
Field	Labrador Tea	2.02 b[1]	1.33a
	Alder	2.24ab	1.53a
	Feathermoss	2.50a	1.95b
Pots	Labrador Tea	2.27c	1.37b
	Alder	2.51b	1.52b
	Feathermoss	2.90a	1.75a

[1] For each trial, column values followed by the same letter are not significantly different at .05 level, Duncan's multiple range test.

Table 2. First season nutrient uptake of container black spruce seedlings planted on operational groups in the field, and on potted substrates associated with these groups

Trial	Operational Group	Nutrient Uptake (mg/shoot)				
		N	P	K	Ca	Mg
Field[1]	Labrador Tea	8.3	1.8	3.5	3.9	.9
	Alder	10.7	2.2	3.9	4.8	1.1
	Feathermoss	19.9	2.8	5.3	5.9	1.5
Pots[2]	Labrador Tea	10.6	1.8	5.6	4.9	1.8
	Alder	14.8	2.0	6.5	6.2	2.1
	Feathermoss	21.2	2.7	7.9	6.4	2.5

[1] Mean of 30 seedlings representing 2 replications per operational group.
[2] Mean of 27 seedlings representing 3 replications per operational group.

Table 3. Effect of fertilization (83 kg N/ha) on nutrient uptake and dry weight of seedlings planted on intact blocks of substrates from 3 operational groups

Operational group/ treatment	Nutrient uptake (mg/shoot)			Seedling dry weight (g)
	N	P	K	
Labrador Tea				
Unfertilized	3.34a[1]	0.43a	1.26a	2.54a
Fertilized	5.50b	0.39a	1.17a	3.09a
Alder				
Unfertilized	2.68a	0.30a	1.03a	1.99a
Fertilized	4.18b	0.28a	0.99a	2.50b
Feathermoss				
Unfertilized	3.75a	0.45a	1.69a	2.59a
Fertilized	5.05a	0.39a	1.24a	2.63a

[1] For each site, values of each column followed by the same letter are not significantly different at the 0.05 level, Duncan's multiple range test.

Table 4. Incidence of frost damage on outplanted seedlings raised under 3 nitrogen regimes

Nitrogen regime	Percent of total seedlings damaged[1]
Recommended N	22%
3 times N	64%
4 times N	62%

[1] Based on 100 seedlings per regime. Seedlings assessed visually for degree of browning.

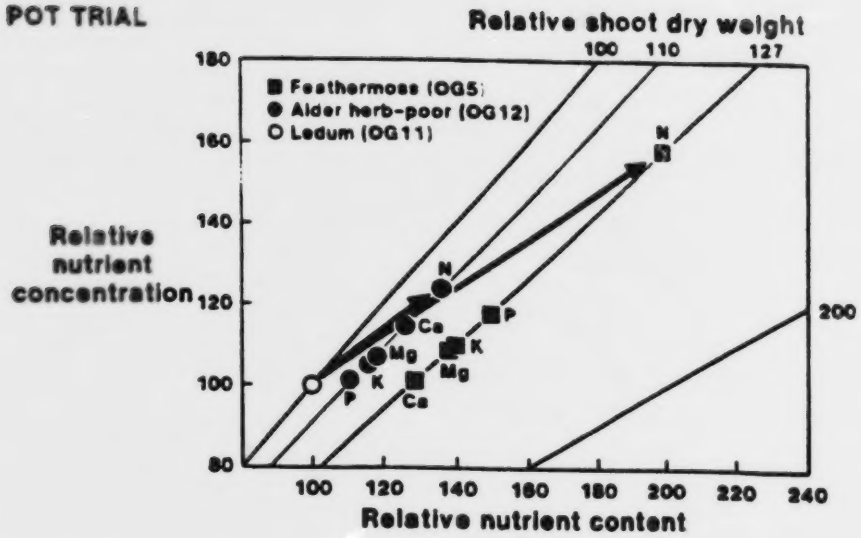

Figure 1. Relative differences in nutrient content, concentration and dry weight among seedlings planted on 3 operational groups (OG). Seedling status of the poorest site (Labrador tea) was equalized to 100 to allow nutrient comparisons on a common base. Refer to Timmer and Morrow (1984) for diagnostic interpretations.

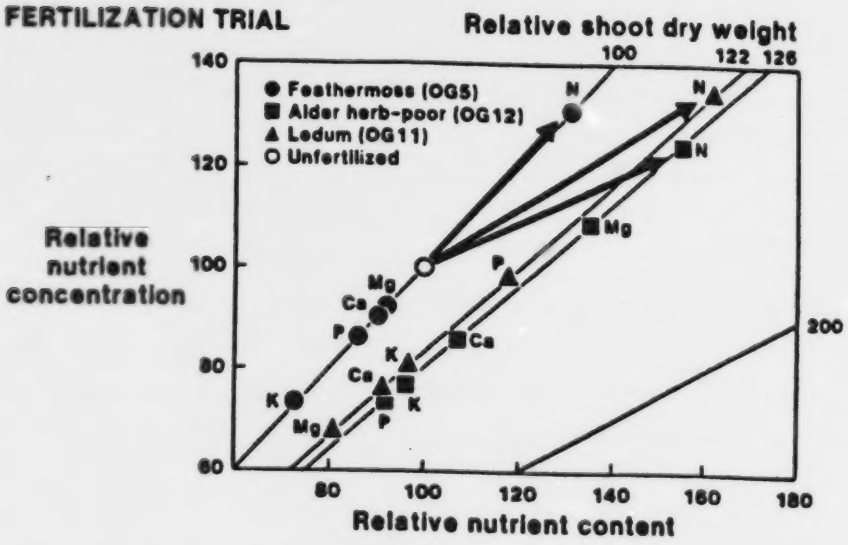

Figure 2. Relative differences in nutrient content, concentration and dry weight between fertilized and unfertilized seedlings planted on 3 operational groups. Seedling status of 3 unfertilized controls were equalized to 100 to allow nutrient comparisons on a common base.

ROOT PRUNING AND WRENCHING

A.J. Campbell
Superintendent
G. Howard Ferguson Forest Station
Ministry of Natural Resources
R.R. 4
Kemptville, Ontario
K0G 1J0

Introduction

Root pruning is really referred to as a process that goes on during tree lifting, and I prefer to refer to work done in the beds as root cutting, because, in actual fact, that is what you are doing. Root cutting is done for one main purpose - to establish a more compact root system.

Many times in our pines and spruces, you will find a considerable number of 'stragglers' and we are trying to make the root system more compact so that you will not have to do that "root pruning" when you lift the trees. If you do a good job on root cutting and root wrenching, you will have a denser root system. This type of work has been done in British Columbia and extensively in New Zealand. Their stock is much different and, as in any other practice, you have to apply their practice to your own situation and your own species.

It has been my experience in the past four years that it does not reduce height growth, but it will reduce the stem caliper. You are, in effect, reducing some of the root area and therefore the dry weight is reduced, and thus, shows up in the stem caliper.

Methods

The timing of the root cutting, where you actually cut the roots, should probably be about a week before you are going to do your root wrenching. This of course depends on the species you are dealing with. The cutting

should be done with a live blade. Our root pruner is made by Grayco, the same people who made some of the earlier tree lifters. It is an oscillating blade that has a slicing motion that goes through the soil. The horizontal cutting should be done first, if the soil is quite stable, and make a very clean cut. The vertical root pruning should be done second. If you do it in reverse order, you are going to find the outside lines of trees will tend to tip over.

The wrenching is not a cutting operation at all. It is done by a rather dull blade. It only has to be sharp so it can slice through the soil fairly easily. The objective here is to shake the tree and make it stop growing. Run the blade under the bed, at quite an angle, so that the whole bed is lifted. The amount of bed you lift depends on the speed of your tractor. The objective is to get the tree up in the air and back down relatively straight. If you start getting trees way off at angles, you have gone too far. If everything comes down exactly square again, then you have not done enough so you have to experiment with this to get the speed of your tractor.

Jack Pine

Most of our earlier work was done in jack pine. The first problem we had to deal with was excessive growth. We had 16", 18" and 20" tall trees which are not appreciated in the field when the planters are on piecework. Root cutting is done about 4 weeks after the growth had initiated and then we leave the bed for about a week.

One thing to remember that root cutting does not disturb the soil excessively. The soil is shaken a little bit but there is no panic. You should irrigate perhaps at the end of the day.

The first wrenching in jack pine is done one week after we do the cutting and you try to estimate this so that you get the height you want to do the wrenching, in our case around 8 inches. When you do the first wrenching, it will stop the height growth. Jack pine is a very persistent grower and two weeks later you have to be out there and shake it up again. We found in most years that three wrenchings will maintain the height. It will also transfer a lot of the height, you

would normally have, onto root growth so that you will get quite an increase in area index. The "top-to-root" ratio is reduced considerably and you get a tree that you would like to plant. Last year, we had a very wet, warm fall and despite three wrenchings, the jack pine put out 4-5" of lammas growth. In some years you have to watch your seedlings very carefully, and if you find that buds are starting to break in the late August, you will have to give it a fourth root wrenching.

White Pine and White Spruce

We have a slightly different objectives in root cutting and wrenching in white pine and white spruce. In both white pine and white spruce we wait until the bud is beginning to form and then we do the cutting.

With white pine, being in much greater demand in our part of the country, we started working with it to see if we could come up with a tree closer to a transplant. The northeastern part of the province where we supply white pine, like a transplant, we root cut and wrench the tree in the bed, this saves a tremendous amount of expense.

We tried some root cutting in the 1+0 year, but we got into a situation where you have to root cut at 2 inches. You can destroy a lot of trees if your root cutter is not adjusted very well. We have put a set of wheels with wide tires on our root cutter and we can now adjust it and maintain its level very well in relation to the adjacent path. This was one of our problems - to have a tractor driver, skilled enough, to be able to hold it at 2 inches. It is working much better now.

The white pine for 3+0 ship should be root cut and root pruned in the second year with a desired number of wrenchings to develop as much root fibre as possible, and then in the third year leave it alone. Let it recover. You have shaken it a fair amount, reduced amount of root, and bud set will be considerably smaller at the end of the second year as a result of this work. You have done all you want in manipulation, let the trees grow, fertilize well, to get a good bud set in the third year. So with white pine and white spruce we will root cut and wrench in the second year and leave it alone in the third year.

We don't have any final data on our white pine. The only thing that I have are some trends. One of the things I want to mention with regard to white pine is that you do all your manipulation of the tree in the second year.

Other species

The larches and 2+0 tamarack tend to be very tall, 30-35" in height. In this case, we wait until the height is almost 8-10", then we do root cutting so that in a week we could follow with the first wrenching.

Questions and Answers

Q. Is there a recommended angle for root wrenching - say, 35 degrees?

A. It is around 30 degrees. It depends on the type of three point hitch you have. The secret is to get a good break in the soil when it rolls over the blade. You have to see the soil cracking wide open and dropping back down so the trees are vertical. I noticed in our jack pine, in 4-5 days, any trees that were not exactly vertical had straightened up. They recover quickly.

Q. Are you irrigating within hours of wrenching?

A. We are irrigating probably within a half hour. This is not recommended in the B.C. work. They recommend that you let your trees go almost to the wilting stage before irrigating. I don't feel this is necessary. We are getting good root fibre development the way we are doing it and I think you run a risk of losing some trees that won't recover if they get to the "wilt" stage.

Q. Do you think you will be able to use wrenching to condition the plants so that you can lift them earlier for refrigeratad storage in the fall?

A. We have been wondering about this ourselves. For example, jack pine is one of the more difficult species to store, also, we certainly have not perfected white pine yet. I think this is a good possibility, but we have nothing to go on at the moment. I think there should be trials

done on this to see whether conditioned stock will store as well or better, or can you lift it earlier. There are many questions to go with that.

Q. Is a heavy application of water after root wrenching is not defeating the purpose as opposed to a light application, just enough so that they do not go into a permanent wiltness?

A. I don't think so. If you read some of the literature from British Columbia and New Zealand, they would lead you to believe that part of the process is the drying that stimulates the buds that form the fibre. One thought says be daring and let it go to the wilting stage, but I guess we are a little bit too cautious for that.

Q. In 3+0 white pine, are you reducing the length of some of those long roots at lifting time and observing less breakage?

A. We are reducing the length of the long stragglers in one direction. Unfortunately, we can only root prune vertically in one direction so that there are a few stragglers that do go along the length of the bed. We certainly have reduced a lot of the stragglers that would cross the rows. We wait until the bud is just starting to form and we dig down and make sure we have roots crossing so that when you do cut, you are cutting something. You are not going to cut them all but you are going to cut a large proportion. To some degree we are boxing the root in one direction. There is still a little bit of cleaver at time of lifting to get rid of some of the stragglers.

Q. Can you measure it in terms of reduced cull at lifting?

A. We have not done this yet. That is a refinement of what we should be doing in measuring the stock this fall.

Comments:
In B.C. they are doing their root pruning to set bud and to prevent frost damage in the fall. Over there, towards the end of September you do not have high temperatures as you do in the spring.

Comments:

In the work we are currently doing in Thunder Bay with somewhat inadequate equipment, we are finding that we cut as early as possible when root generating potential is as high as possible. We try to do that early in May. Treatments that are initiated as early as that are wrenched repetitively at 21 day intervals through the season, limit the growth of buds and we believe that improved size of the roots is a function of reallocation of material to the roots because of the reduction in the effect of the terminal bud on the tree metabolic process. You change the shape of the tree.

In the matter of watering - do you or don't you? I think there are some conditions you must water but I don't think its watering or not watering that's rather critical but I think what the wrenching actually does it as it fractures the root system to a degree also. It actually breaks new soft tips and causes proliferation and as we don't want to have seedlings die so we tend to water in June and July. It is foolish not to do so, otherwise we are going to lose too much of the crop.

General Comments:

The loss survival records at our nursery show we had erratic success when we seeded in the fall. White pine was up and down, for many reasons. But one of the reasons was associated with weather. By spring seeding, you can cut out six months of weather that you don't have to contend with. In 1980, we had no snow in February. The flooding and frost followed.

We lost in the white pine fields over 60% of the seed. Since we have gone to spring seeding, we did eliminate all that. Many people felt that white pine still had to have natural stratification in order to get good germination. But over a three year period we had 60-70% germination which is as good as we ever had.

A NEW LOOK AT SEEDBED MULCHING

G.D. Racey
Research Biometrician
Midhurst Research Station
Ministry of Natural Resources
Midhurst, Ontario
L0L 1X0

Seedbed mulching has performed a number of functions over the years and the nature of the mulching treatment has changed with the perceived needs and objectives. Mulching for seedbed stabilization has been the dominant function at Ontario nurseries, with temperature regulation being a secondary objective with some species.

Straw mulching was widely used for both spring and fall seeded nursery beds in the 1950's and 1960's (Mullin 1965). However, standardized mulching practices were never adopted. Rate of straw application, source of straw, time of removal and pre-mulching treatment of the straw varied with each nursery. Straw was usually held in place by wood-lath shades but this too was not consistent among all nurseries. In the 1970's, hydromulch was adopted because of its ease of application, absence of weed seeds and reduced cost. Two types of hydromulch were used; one a wood cellulose fibre (Conwed Hydromulch)[1] and one a recycled newspaper product (Fibramulch)[1]. The recycled newspaper products is now most widely used in southern Ontario nurseries.

Straw mulch was found to be superior to Fibramulch in seed germination and seedling size for fall seeded beds at Midhurst nursery (Racey and Raitanen 1983). Various application rates of hydromulch were tested for their effects on germination and growth of white spruce (Picea glauca [Moench]

[1]The mention of brand names in no way implies endorsement of the product.

Voss) and white pine (Pinus strobus L.). A significant relationship between application rate and seedling performance has also been observed (Racey and Raitanen 1985). On white spruce beds, the final bed densities and seedling size at the end of the first growing season were inversely proportional to application rate; the higher the rate, the poorer the performance (Racey and Raitanen 1985).

The results of this work have shown that there is still much to be investigated in the area of seedbed mulching and that a better understanding of the properties and effects of these mulches is required.

Therefore, our 1985 work program on mulching has been developed along two themes: 1/ to try to determine if seedbed temperature and hydromulch application rate are correlated with seedling performance; and 2/ to determine if new sprayable latex mulches have any benefits to soil temperature or seedling performance when applied to newly seeded beds.

Hydromulch density trials

The hydromulch density trials were conducted on white spruce and white pine at Kemptville nursery and white pine and red pine (Pinus resinosa Ait.) at Midhurst nursery. Fibramulch was applied May 2 and May 3 at Kemptville in a randomized complete block design with 5 application rates and 5 blocks (Table 1). Soil temperatures and germination counts were taken 2 to 4 times between date of seeding and June 21, 1985. Soil temperatures were measured on sunny days as instantaneous measurements between the hours of 10:00 and 14:00 at a depth of 0.2 to 0.5 cm.

Soil temperatures varied significantly with mulch application rate at both Kemptville (Figure 1) and Midhurst. Also, the response in seed germination corresponded well with temperature responses at Kemptville (Figure 2) and Midhurst (Figure 3).

These results were obtained before germination was complete but they clearly indicate a reduced rate of germination with the heavier application rates of Fibramulch. This will lead to reduced seedling size at the end of the 1+0 year and hence an increased probability of frost heaving and reduced quantity of stock for transplanting, if desired.

Further information to be obtained this year will be final germination rates, seedling survival, top and root dry weight and stem caliper of 1+0 seedlings produced. In addition, toxicity tests will be conducted to determine if the Fibramulch itself contains residues or chemicals which can reduce germination or performance. These results will be made available when obtained.

Latex mulch trials

Latex is a commonly used product in modern society and has been used recently for soil stabilization in land reclamation projects. Latex generally forms a film and adheres to soil particles, therefore creating a moisture resistant, binding layer on seedbeds. The latex is applied as a liquid (40-70% solids) by any spraying device, such as would be used for herbicides or insecticides.

The major objective of our testing program is to determine if latex mulches can play a role in nursery seedbed mulching.

Two products are being evaluated from two Canadian companies. Of the two products, one contained a black pigment to try to enhance soil temperature, the other had either a white pigment or no pigment added. These products were applied on the nursery beds with a Solo backpack sprayer in .3 m plots laid out in a randomized complete block design with 5 blocks. The treatments and application rates were dependent upon nursery and compartment in which they were used (Table 2). Operationally, these would be applied by a standard herbicide sprayer.

At present it is too early to draw many conclusions from this study but it is apparent that 1/ the dark latex mulch produces a higher seedbed temperature than the control plots or the light coloured mulch and 2/ no systematic differences in germination rates have been observed among treatments. This suggests that temperature alone may not be as important as various other properties such as mulch composition or structure.

Observations of mulch texture would indicate that strong film-forming characteristics of a latex mulch are undesirable. Soil binding without film-forming, such as with a product of lower viscosity would probably be more desirable. However, until final germination and field performance measures have been taken in October 1985, these conclusions are tentative.

Summary

There is no conclusive proof from any of our past work that seedbed performance is improved through modern mulching methods (Racey and Raitanen 1983, 1985). Light applications of Fibramulch, less than 0.1 kg/m of bed provide higher soil temperatures and better germination but does not seem to provide the necessary soil retention properties to avoid serious seedbed disturbance from heavy spring rains or strong winds. One must balance soil stabilization with seedling performance, especially with the smaller seeded species (Racey and Raitanen 1985). Landis et al. (1984) also noted the importance of lighter application of hydromulch but also found that mulched beds outperformed control plots for western conifers.

Latex mulches are still very new and are not currently recommended. Much more work is required before operational trials are feasible.

At present, Fibramulch still appears to be the best product available but rates of application between 0.10 and 0.20 kg/m of bed are recommended to give best seedbed stabilization with least reduction in seedling performance.

References

Landis, T.D., J. Lott and J.A. Ives. 1984. Hydromulch increases seedbed density of some western conifers. USDA For. Serv. Tree Planters Notes 35: 3-7.

Mullin, R.E. 1965. Effects of mulches on nursery seedbeds of white spruce. For. Chron. 41: 454-465.

Racey, G.D. and E. Raitanen. 1983. Seedling development as affected by fibre and straw mulching at Midhurst nursery. Ont. Min. Nat. Resour. Nursery Note 94. 5 p.

Racey, G.D. and E. Raitanen. 1985. The effects of fibramulch application rates on conifer seedbeds. Ont. Min. Nat. Resour. Nursery Note No. 114. 4 p.

Table 1. Application rates (kg/m) of Fibramulch applied at Kemptville and Midhurst nurseries in spring 1985

Application Rate	Kemptville			Midhurst	
	Sw	and	Pw	Pw	Pr
Control		0		0	0
Low		.077		.056	.058
Med. Low		.107		.082	.115
Medium		.154		.111	.161
High		.270		.186	.269

Table 2. Application rates of Latex mulches (dry g/m^2) on seedbeds at Midhurst and Kemptville nurseries. Two brands of mulch were used, General Latex (GL) and Polysar (P), each of which was available in a Pigmented (P) and non-pigmented form (NP) to provide dark and light coloured mulch respectively.

Brand	Application rate	Colour	Application rate (dry g/m^2)
GL	heavy	P	120.990
GL	light	P	40.474
GL	heavy	NP	101.615
GL	light	NP	34.015
P	heavy	P	215.823
P	light	P	72.121
P	heavy	NP	170.614
P	light	NP	57.051

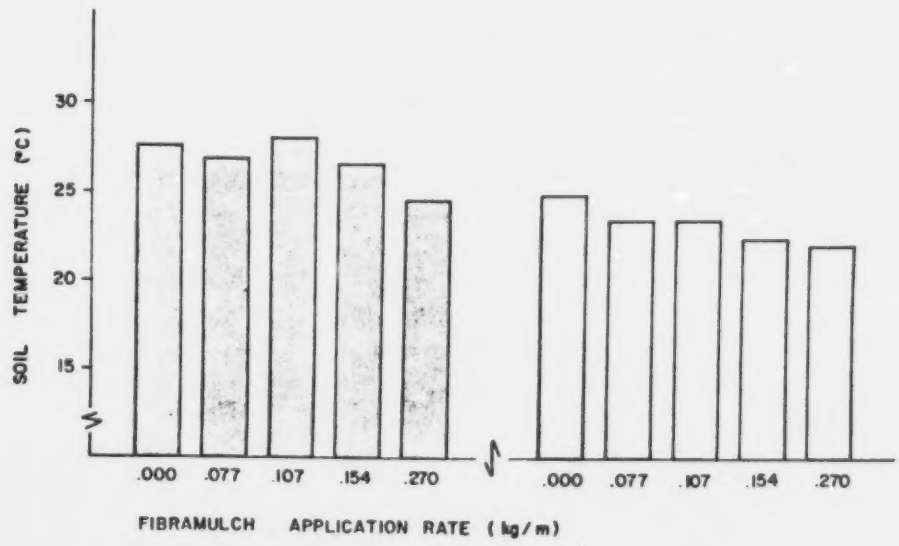

Figure 1. Average soil temperature measured between 0.2 and 0.5 cm depth in two Kemptville compartments in response to application rate of Fibramulch.

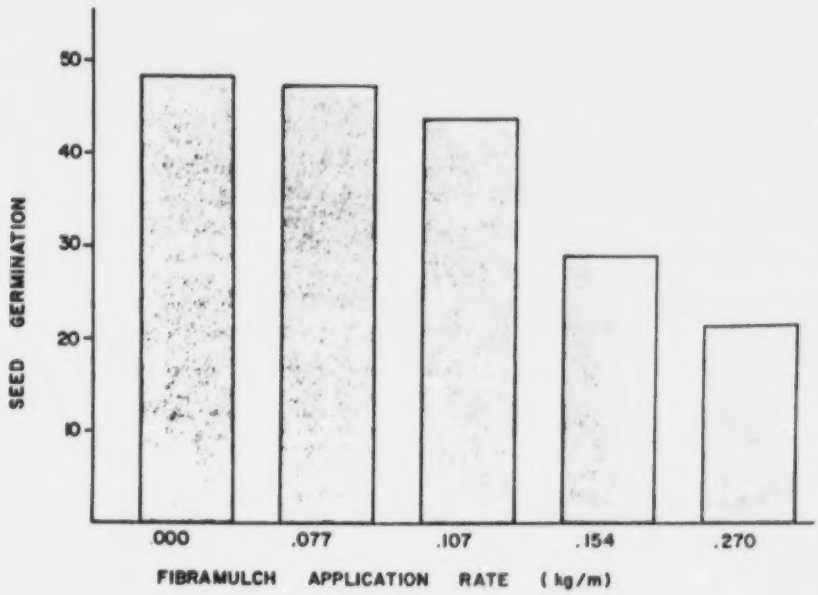

Figure 2. May 29, 1985 seed germination (seedlings per sq. ft.) of white spruce sown in Kemptville, compartment B-14, May 2, 1985.

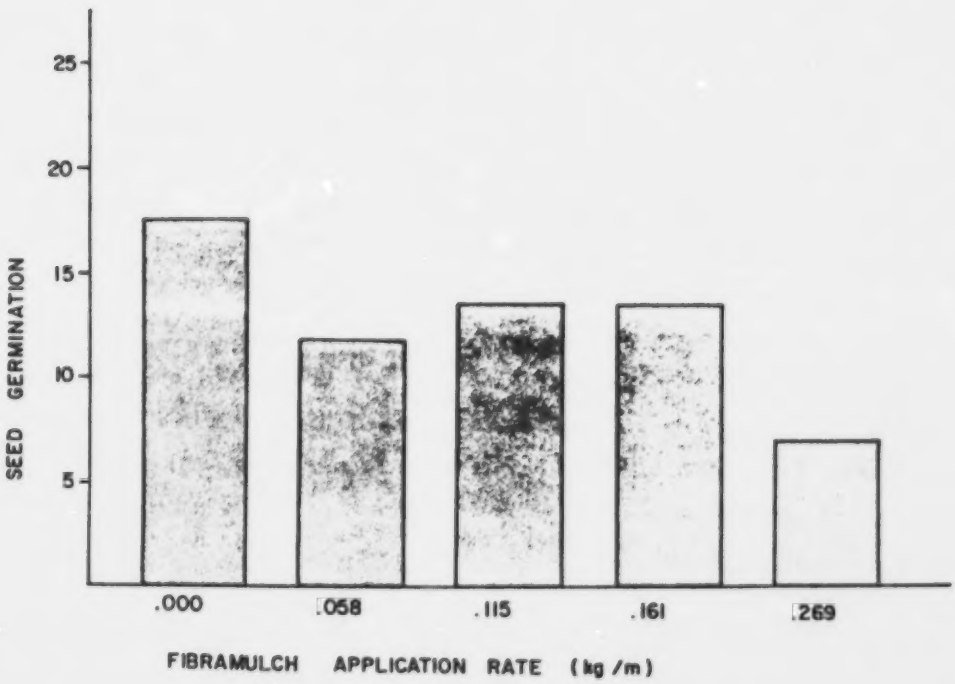

Figure 3. June 17, 1985 seed germination (seedlings per sq. ft.) of red pine sown in Midhurst compartment C-3, May 16, 1985.

THE POTENTIAL FOR STEROL-INHIBITING COMPOUNDS IN FOREST SEEDLING PRODUCTION

G. Hofstra
Department of Environmental Biology
University of Guelph
Guelph, Ontario
N1G 2W1

Introduction

During the last few years a new group of compounds have been produced that are primarily fungicides, but they also have effects in regulating plant growth. These compounds are generally effective at extremely low concentrations, much lower than most of the pesticides presently in use. Many of the compounds are still at the experimental stage, some are actually less than two years old. Very few are at the stage where they have been licensed for use.

One area where these compounds have potential is in the area of plant hardening. These compounds have the effect of increasing hardiness to various stresses such as drought, low or high temperature, salinity and pollutants. We had been doing some work on winter hardiness and dormancy in trees in relation to our work on the causes of multiple leaders in spruce. Hardening of tree seedlings can be a problem in the fall because of high temperatures, excess nitrogen in the field, or in greenhouse production.

Testing for winter hardiness

In our work with winter hardiness, we have been using a test mechanism that is somewhat different from the one being used at Maple and allows for the assessment of relatively small differences in hardiness. The method we have been using is more precise, requires a smaller sample, looks directly at the buds and can be readily done by anyone who wants to set up the test.

The people at Orono have been interested in setting up this test and Glenn McLeod has asked me to speak on it today. Basically all that is

needed is a freezer that can be modified so that the temperature can be dropped accurately and in a graded fashion. At the University of Guelph a number of these are in operation of various designs, because of the large amount of work being done on winter hardiness in crops. There are two methods being used to control the gradual decline in temperature. In the older models the amount of refrigerant going through the cooling coils was controlled by placing a valve in the system. A clock mechanism controls the gradual opening and closing of the valve. The newer models have gone to electronic control. In this case, the thermostat is connected to a wheel that sends signals to the thermostat, again accurately controlling the rate of cooling. Almost any freezer can be modified for this purpose. The mechanism must allow the temperature in the freezer to drop at about 1 to 2°C per hour and hold the temperature at any desired point. For accelerated transplants, the temperature need go down to only about -10°C. By the time the buds will survive that temperature, the trees should be ready for storage.

In the tests for hardiness that we run, we cut about 1 cm from the tip of the terminal and place ten of these, slightly wetted to encourage ice formation, in a plastic bag. A number of these bags are placed in the freezer, the temperature is lowered to just about the freezing mark and the buds are held there for about 12 hours. Then the temperature is gradually lowered at 1 or 2 degrees per hour. A bag can be removed at 1 or 2 degree intervals as desired. The bag as it is taken from the freezer is placed in styrofoam chips in the refrigerator to allow the temperature of the buds to rise gradually. After several hours the buds are gradually brought to room temperature. To test whether the buds have survived freezing down to the temperature at which they were removed from the freezer, the buds are cut longitudinally down the centre and placed in a solution of the stain tetrazolium chloride. This stain responds to a number of enzyme systems involved in respiration, and turns from being colourless to pink or red depending on the degree of respiratory activity. After several hours the buds are examined. If they are red they are alive, but if they have been killed they will come out green, or brown if they have been dead for some time. The test is fairly simple and quite accurate.

Larger buds are easier to work with then small buds on 1-year old spruce seedlings from the field. The red colour becomes generally visible first in the tip of the stem, and then stains the various tissues in the bud. It is possible that the stem tip would stain, but not the bud, indicating that the stem tip is alive but the bud is dead. It also happens that the bud stains but the stem tip does not. In this case the bud is still alive, but because the stem tip did not survive a specific temperature, the bud would also die at that temperature in intact seedlings.

Growth regulator potential in conifers

We have become involved in looking at the various growth regulating effects of the new sterol-inhibiting fungicides and growth regulators. These compounds of which there are many have a mechanism of action in common in that they block the formation of sterol compounds in fungi, thereby killing them. The metabolic pathway that produces the sterols also exists in plants and produces a number of plant hormones as well. When these compounds are applied to plants for disease control, a number of growth modifications can be observed. The plants are generally a darker green and shorter. This was how their growth regulating effects were first noticed. It has since been demonstrated that these compounds block the synthesis of gibberellic acid in plants, the hormone that influences elongation, bud dormancy, and flowering in biennials.

Most of our work to-date has been done on crop plants, and there we have seen a number of effects. Plants became more tolerant to most environmental stresses. Plants sensitive to chilling injury showed no injury down to the freezing mark when they were treated with one of the compounds. Plants that normally harden to frosts were tolerant of freezing temperatures when treated, even though they had never been exposed to hardening conditions. The same has been observed for drought stress and for high temperature stress. These compounds make the plants more stress tolerant without any acclimatization. The compounds appear to make the plant do what it normally would in response to acclimatization. Thus a plant, such as bean, that cannot normally be harden to frost will also not become frost tolerant when treated with these compounds. A plant such as cabbage, which can harden to several degrees of frost, does become frost tolerant on treatment. Hardening down to about -6° has been obtained in winter cereals on treatment.

Treatment with these compounds also makes the root systems more tolerant to stress, as we have seen at high temperatures. An interesting side effect of these compounds is their ability to enhance rooting in plants. We have seen substantial increases in the size of the root systems, or greatly increased rooting of cuttings. Increased rooting of cuttings was obtained whether the cuttings were treated, or whether the plant from which the cuttings were taken was treated several days in advance of taking the cuttings.

Most of our work so far has been with the compound 'triadimefon' which is being marketed as Bayleton. It has only limited registration in Canada so far. A compound very similar to it is 'triadimenol' (Baytan). More recently we have been working with some Japanese compounds that have just been made available for research. These are about 100 times more active but still have similar effects. Some of these compounds are being developed as fungicides but they have growth regulating proporties, others are being developed as growth regulators but they also have fungicidal proporties.

The effects of these compounds appear to be through a combination of metabolic changes in the plant. As already mentioned, the formation of gibberellic acid is blocked producing some of the observed effects. However, the level of other hormones is increased such as the level of abscisic acid and cytokinins. The effects on greening and delay in senescence are probably due to cytokinin, whereas the effects on hardening are probably due to a temporary rise in abscisic acid. The production of ethylene is also altered and this may influence rooting. Some of the effects may be the result ot an increase in polyamines, but this has yet to be confirmed.

We have started some preliminary work with trees, partly on the urging of Glenn McLeod. There are a number of areas where the production of conifer seedlings could benefit greatly from the use of growth regulators. Injury from stress shows up in various situations. Transplanting subjects the seedlings to moisture stress, it is often difficult to get the fall crop in the greenhouse hardened off sufficiently before the seedlings need to be placed in cold storage or outside for overwintering. Survival is often poor on outplanting because of drought or slow development of new roots. Our initial work with trees has shown that much higher concentrations of the compounds are needed in conifers than in crop plants to produce the same

effect. We are not sure of the reason for this. It could be that the compounds do not get into the conifers as readily, or they are being tied up once they do enter, or conifers simply need a higher concentration in order to respond.

In spruce seedlings we have noticed increased greening on treatment. In one case, treated and untreated plants were accidentally exposed to high temperatures and drying conditions when the temperature control on our growth room broke down. The untreated seedlings all died, whereas most of the treated seedlings survived.

So far it has been very difficult to get funding to work with these compounds in conifers. There are all kinds of potential there in forestry if we can find a compound that is effective on conifers.

Questions and Answers

Q. Have you done work on trying to combine the effects of controlling shoot growth and root growth either alternately or at the same time?

A. Most of this work is still new. Basically, we are at the point where we are testing what the effects on various stresses are and what concentrations are needed to get minimum growth reduction, and yet get the protective effects against stress. Most of this work is less than a year old.

Q. Was this work developed for fungicide purposes?

A. There have been various compounds that are sterol inhibitors but are not fungicides. Some of these are growth regulators, but none have been developed for use so far to the licensing stage. Triadimefon is being used in a number of countries where the greening effect and greater tolerance to stress have been noticed. Plants are more drought tolerant. Tea plants in India were much greener and drought tolerant, and it was this type of observation that has led to the work on stress resistance. The one compound that has been pushed as a growth regulator, particularly in the horticultural industry, has been paclobutracol (PP-333). It is being tested quite widely and also on

trees. Apparently on weeping figs in office buildings or shopping malls it keeps them green and stops elongation under low light conditions. Various applications are being tried for this compound, but with growth regulators there is a real problem getting them licensed. There is usually insufficient demand for them to warrant companies putting large amounts of capital into their development. The ones being developed as fungicides have a much greater chance of making it on the market as growth regulators. It is much easier to extend the licence on a compound than to get a new registration for a rather limited use.

Q. You were saying that some of these compounds do effect the ageing of the plant. Has there been any work done on looking at bud formation?

A. I don't know whether anyone has looked at it or not. Most of the work done with PP-333 has not yet been published. It is being worked on in apple trees for example. The concentration at which the chemical is applied is rather critical. If PP-333 is put on at too high a concentration, growth stops and the plant will just sit there for months or longer.

Comment

We did some work with gibbrellic acid on western hemlock in British Columbia. We found that it did slow the growth in the latter part of the season, but the problem was that it continued on into the next year.

The concentration of these chemicals is quite critical. If you get the concentration too high you can get severe growth reduction.

Q. Can you apply it with a surfactant to get better uptake?

A. We have not had to add surfactants over whatever surfactant may be in the formulation supplied by the company for use on crop plants. Some of the compounds are wettable powders, others come as a liquid. To work on something like conifers we may have to add additional surfactant. So far the chemicals have worked best applied as soil drench, but the newer Japanese compounds are just as effective as foliar application. Triadimefon works far better as a soil drench. We don't know whether we

are getting better uptake through the roots, or whether the compound is producing certain changes in the roots that affect the rest of the plant. Triadimefon is mobile in the xylem, so it does get to the top of the plant when you apply it to the roots. The other compounds may be systemic as well, although we have not seen anything published on that yet.

Q. I would like to ask a question about the tetrazolium chloride. How sensitive is that test? For example, could we detect winter damage on container stock or nursery stock? If you do a freezing test, is there a range of temperatures that work best, for example, down to -6, -10 or -25 degrees C?

A. Basically what the technique picks up is the respiration rate, so after we have frozen the tissue we bring it back up to room temperature to get the metabolism going in the tissue. If you do the test at the freezing point, you will be waiting forever for the colour change to take place because the respiration rates are so low at that temperature. Therefore it is important to have the tissue at room temperature, so that if the tissue is alive you will have a high enough rate of metabolism to get a colour change in a few hours. Any tissue that is alive and respiring will turn red, whereas any tissue that is dead will show no response unless there is a lot of fungal or bacterial contamination. In that case, the tissue may also turn red, but it will be brown rather than green to begin with. Thus, the test can be used to look at tissue that has been treated with any temperature. The compound tests for viability of the material, and is very sensitive. If tissue is alive it will carry on respiration, and therefore turn tetrazolium chloride red.

Q. Could you use this test to determine your lifting time or storage in the fall? This is as opposed to using the other tests around.

A. I don't know. We haven't tried it. If it is possible to work out a relationship between the degree of hardiness and the respiration rate it should be possible. It is possible to quantify the amount of red colour produced in tissue. We ourselves have used it to measure the rate of respiration in root tips. It would mean having to standardize

the technique in terms of the amount of tissue taken, the length of time in the stain and the temperature at which it is done. You would then have to extract the stain and measure it with a spectrophotometer. It is somewhat doubtful whether the eye would be sensitive enough to pick up the differences. You would also need a standard against which to compare it. The buds and roots continue to metabolize even when they are dormant, but it may well be at a much slower rate.

HAND-HELD DATA ENTRY DEVICES FOR FORESTRY

D.C. MacIver
Mensuration Specialist
Timber Sales Branch
Ministry of Natural Resources
Whitney Block
99 Wellesley Street West
Toronto, Ontario
M7A 1W3

Where we started

This project was initiated one year ago at the Ontario Tree Improvement and Forest Biomass Institute (OTIFBI). Most of us share the same problem. There are numerous hand-held data entry devices in the commercial marketplace, yet few are suitable for forestry applications. The question remains, which one do I buy?

In addition, we recognized that there are a number of units currently in use within the Ministry. But because this is a fast-moving technology, we decided to take a more rational approach by engaging in a marketplace survey. Partial funding was made available through the Environment 2000 program which allowed us to assemble a Data Entry team - an electronics specialist plus a computer programmer. The more they looked the more they found. Their evaluation was documented in an internal report (MacIver, Green and Allison, 1983).

What we were looking for

A short list of machine specifications for forestry applications was assembled which directed the search for relevant hand-held units.

Power supply is a major problem with most portable data entry units. There is little sense in purchasing a field unit if you can't either replace the batteries in the field or be guaranteed that the batteries will function for the time required to be in the field location. In all cases a second set of internal batteries are essential to maintain memory, if the primary batteries fail, or need replacement.

Environmentally protected units from black flies, snow, rain, dirt, etc... The terminology defining environmental protection ranges from total sealants to raincoat enclosures to essentially the plastic case defined as the environmental protection. Total sealants on the solid state circuitry are ideal but can present servicing problems.

Portability is essential. The smaller and lighter the unit the better. However, if this reduction in size means that the keys are too small for the gloved hand then little is gained, yet on the other hand a large unit requiring a neck strap for support can be extremely cumbersome.

Useable memory, that is the ability of the unit to store data. Different units utilize a variety of technology to separate (or reduce) the operating memory from the useable memory space reserved for data capture and recording. This memory must be expandable.

The operating language should be easily programmed by the casual user. This can include the language supplied by the company or by a third party supplier e.g. BASIC, FORTRAN, etc. Coupled with this, of course, is the need for standard and complete Keyboard functions and the ability to redefine the keys for specific functions, e.g. in a regeneration survey, the keys could have tree species silhouettes superimposed on the keyboard. Compatibility in the support languages with other microcomputers is essential to enable the application programs to be developed on an external microcomputer, then downloaded directly to the hand-held data entry unit.

Data input should not only be direct from the keyboard but also from external sensing devices. A good example is the electronic scanning of

Bar Codes. To a large extent, forestry does not, as yet utilize this technology, i.e. inventory management, but does require the same form of digital input from electronic calipers. For example, we reviewed the Fowler Industry Electronic Calipers and a number of Ministry personnel have purchased these units for root collar measurements at nurseries.

Data output via RS 232 communication is mandatory on any hand-held unit. This can be either handwired directly to the microcomputer or telecommunicated via a modem linkage over the telephone. By maintaining the RS 232 standard, then communication with Digital, IBM or Apple microcomputers was established.

Servicing is another concern. It is important that the units can be serviced locally or within 48 hours turn-around time. This generally means that companies must have some kind of performance track record on their product and servicing agreement.

What Companies did we look at

With the above list of machine specifications in hand, we looked at over 100 companies of which approximately 20 showed some promise for forestry.

We also started fairly idealistically, hoping that we could find one unit that would satisfy three general areas of forestry use. Obviously, these hand-held units must be field operational. However, when not in the field, then can this same machine operate as a data entry terminal in the office? For example, can we contract data entry to local residents in the neighbourhood with payment based on the number of bytes of data downloaded to the microcomputer?

The third area of use concerned their stand-alone capabilities. In other words, can we install this unit at the base of a micro-meterological tower, record the atmospheric sensor data and wake itself up at specific periods to telecommunicate the data to the local microcomputer.

As I stated earlier, we began idealistically and soon realized that we could not satisfy all three areas of use. Therefore, the survey focused on two distinct areas - the field and office use versus the stand-alone mode.

In terms of the stand-alone logger, we undertook a separate review, produced a report and focused on the CR21 micrometerological data logging system. Subsequently, the Atmospheric Environment Service installed a system at Maple, and now Thunder Bay and Chapleau Nurseries have the CR21 systems. In addition, the Ontario Ministry of Agriculture and Food are following our lead and looking at the same CR21 systems for their agricultural colleges.

However, for office and field use a more extensive testing program was required. Of the 20 companies, many supplied their product on a one week trial basis. From this short list two manufacturers were selected for further field testing. This year a Provincial test program was initiated by the Timber Sales Branch. For example, the attached Figure 1 illustrates the flow diagram for the proposed silvicultural application.

What we found

The first manufacturer's product to be tested was the California-based MSI company. Five MSI 88s units with expandable memory up to 128 K were purchased from the Toronto outlet.

The MSI has a very tight, but pliable rubber skin raincoat which makes it environmentally protected. There are a number of neck and wrist straps for operation's convenience. The keys are fairly large and well marked, so that data entry, while wearing gloves, is error-free.

The MSI is a data logger with limited intelligence - it is not a micro-computer. The company provides two levels of software support. For general utility, use the Autogen Software which was purchased and licensed to the Ministry and reflects a $600 saving per unit. This software comes enclosed in program load modules (eproms) which are almost indestructible and ideally suited for field use. In the same way, application programs can be burnt onto the eproms, carried with the operator in the field and downloaded in remote locations. This can be a distinct advantage for regeneration surveys.

The second level of software support is more detailed for either IBM or Apple microcomputers. In this case, extensive software application programs with branching capabilities, arithmetic operations and validation checks

were developed on the microcomputer then downloaded to the MSI 88s unit. Again, this licence agreement was signed with the Ministry.

Once the application program is installed in the MSI 88s memory, many features are available to the casual operator. Specific keys control the up or down scrolling through the recorded data sets. This also includes complete editing to allow the operator to return to any point in the data and change the data, if required.

For operators in need of coffee breaks, etc., when the machine is turned off and later turned on, it remains at the same data entry point. In addition to searching for specific data, paging and back-spacing, the machine accepts either alphabetic or numeric data. The "stats" key monitors the current condition of the batteries and the amount of memory available.

The batteries are not rechargeable - the primary batteries have a secondary back-up battery which guarantees that memory is not corrupted during battery replacement in the field.

The software programs can include validation and range checks during the data entry process. For example, if certain fields are defined as alphabetic only and the operator attempts to enter numeric data, the machine responds with a series of audible "beeps."

Many casual operators describe the MSI 88s unit as the most "goof-proof." Servicing is available in Toronto with excellent turn-around guarantees.

The second manufacturer to be tested was DAP Industries, Quebec City. Four microflex units were purchased for test.

In this case, the unit was a CP/M based microcomputer with again 128 K memory, but expandable up to 500 K.

The unit is completely sealed with batteries recharged via an associated moducom unit. In addition, the moducom serves as the RS 232 communication port and requires AC power.

Because this unit is a CP/M microcomputer, it supports a number of third-party languages such as BASIC, FORTRAN, PASCAL, etc. In other words, this unit offers more than the MSI in that it is a data logger with intelligence. For example, where equations, look-up tables, volume tables, etc., are required in the field (e.g. W.I.A. agreements, randomized inventory at nurseries), then this unit can be used because it has the mathematical capabilities. It can be programmed to provide range checks, error detection, alphabetic and/or numeric data verification, scrolling, editing searching and file-communication verification. For example, only the Microflex could satisfy the integrated irrigation trials at Goodie Lake North Seed Orchard, Sioux Lookout, Ontario.

In addition, this unit can drive external screens, printers and disc drives directly plus communicate with Digital, IBM and Apple microcomputers in a master/slave relationship. Programming can be expensive yet provided a greater degree of flexibility for a range of forestry applications. Again, excellent servicing is available in Quebec City with fast turn-around.

In both cases, the MSI and Microflex units are equivalent in value (less than $3,000), yet each unit has different attributes for different forestry applications. The former is a data logger with limited intelligence, whereas the latter unit is a data logger with intelligence. But in all cases, the hand-held data entry devices are only one part of the complete data entry, analysis and interpretation process. It should be implemented and coded accordingly.

Reference

MacIver, D.C., S. Green and M. Allison. 1984. Portable Data Loggers and Electronic Clipboards. Internal Report. Ministry of Nat. Resour. p. 79.

Questions and Answers

Q. Say you have several programs and you are out in the bush, are there separate spaces for programs?

A. At the present time, I have four different programs on this unit.

Q. How much money is that unit?

A. The MSI and Microflex are less than $3,000 each which includes the modem and the battery recharger.

Q. Is the modem really useful?

A. It is essential because this is your only method of communication. In the field you would put your acoustic coupler into the RS 232 connection and then transmit over the nearest phone line. However, you should verify that the Bell lines are capable of clean data transmission.

Q. We have an MSI 88s. We found that the looping capability was not what we needed. You mentioned the Autogen, are you developing any software?

A. There are three programs on the MSI unit right now. All of them have branching capabilities.

Q. We found that when we branched we had to branch right back to the beginning.

A. That depends on how you define your original program. You don't have to go back right to the start. The start will redefine a new file for you if you do that. All of these features can be programmed into the unit including the rebranching entry point.

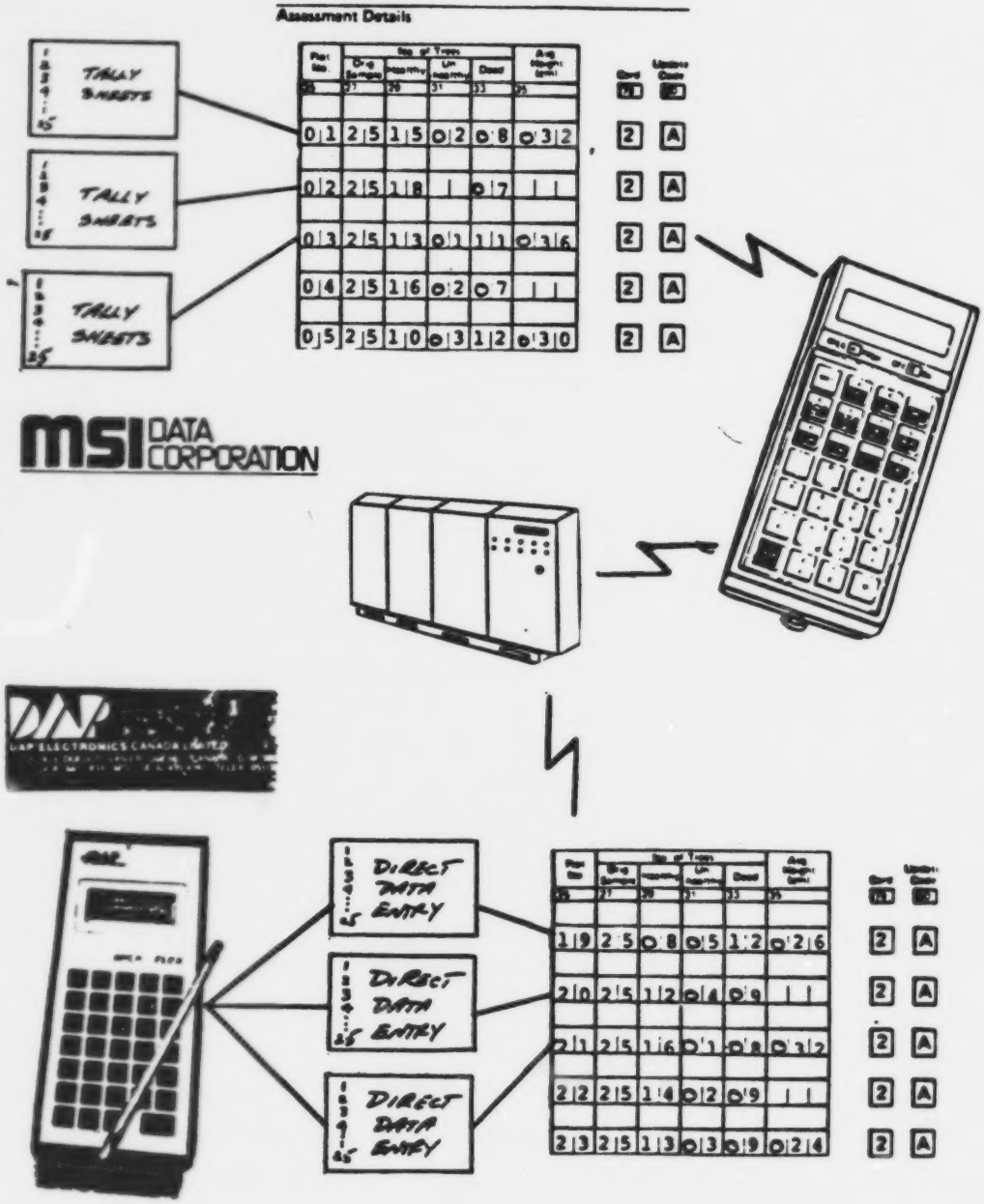

Figure 1. The flow diagram for the proposed silvicultural application.

BRITISH COLUMBIA NURSERY PRODUCTION

C. Kooistra
Woodmere Nursery
Telkwa, British Columbia
V0J 2X0

Introduction

The nursery program in B.C. consists of three sectors:

1) The Ministry of Forests
2) Forest Licensees
3) Commercial Sector

There are a total of 34 nurseries. The bulk of the nurseries deal with the container system. However, that is misleading because many of the Ministry of Forest nurseries are bareroot and container facilities. Geographically, the nurseries are spread throughout the province with the exception of the far north. The greatest concentrations of facilities are to be found in the most favourable climatic conditions: Vancouver Island, the lower mainland, the Okenogen Valley and the isolated areas of Smithers, Terrance and Cornell.

There are 15 species grown by the nurseries in the province. The program size currently stands at 180 million seedlings sown in 1985, with the production coming out of the nursery this year to be 100 to 110 million seedlings.

Overview of the program by species

The bulk of the bareroot capacity lies in lodgepole pine. This is a change that has happened over the past few years. The bulk of the capacity used to lie in the interior spruce. A transition has taken place from bareroot interior spruce to container interior spruce. The spruce encompasses two species: engelmann spruce and white spruce, and the hybrids of both. The problem was they hybridized so frequently that it is difficult to determine which is pure.

The bulk of the production lies in the 1+0 classification. Work is being done with 1+0 lodgepole pine on the coast where there are suitable climatic conditions.

A large portion of the balance of these species is sitka spruce for the coastal sites in B.C. There is also grand fir, noble fir, ponderosa pine and western white pine. The western white pine is even more susceptible to the blister rust than the eastern white pine. Research in Idaho has given hope to again planting this species. Interior spruce is up to 53% of the production with 71 million trees being produced in containers. The significant factor is the 90 million trees being produced in the 2+0 stock type in containers. Lodgepole pine is the next major species with 21 million trees.

Western red cedar and western hemlock make up the bulk of the 15 million, most of which are for coastal sites but also for some interior sites. Others are sitka spruce, ponderosa pine, western larch, western white pine, yellow cedar, mountain hemlock and the three fir species: grand, red and noble fir. This is the size of the program to date.

To simplify, the comments are being narrowed to the three major species: Douglas fir, interior spruce and lodgepole pine, which make up 87% of the total production in B.C.

In March 1985, the Ministry of Forests announced an increase in the nursery program to 200 million level annually by 1987. This reflects a 50% increase over the production level for 1985. With the signing of the federal-provincial agreement in May, this program will be realized. The majority of this increase will be in lodgepole pine and interior spruce as the agreement is to restock NSR lands in the interior. The increase will occur in the commercial nursery sector.

Bareroot program

There are standards that a nurseryman must strive for. These are given by stock type. The stock standards are listed in terms of minimums and targets. Targets are what is tried to be attained and minimums are what the cull level is at.

Culture program

This is the normal sequence of seedling production in the nursery. Fallow and soil preparation techniques have not changed in the last few years. We are finding that during the fallow year, if a field is rolled, then residual weeds will germinate substantially faster. The field is disced and rolled again, again to encourage more seeds to germinate. The result has been a reduction of weeds in crop years. In B.C., herbicides are used sparingly. Work is being done with Round-up and Gesagard.

Our seeding of bareroot crops has changed markedly in the past few seasons with the advent of precision sowing equipment. Two machines are used at present. They are the Summit Seeder from New Zealand and seeder from Germany. Both machines have improved our performance in terms of producing more stock of acceptable quality. The species that are precision sown at present are lodgepole pine and Douglas fir. Recovery is expected to drop slightly per linear meter of bed sown in lodgepole pine. Attempts have been made at precision sowing with interior spruce, but reducing the density evokes a greater risk of frost heaving. The interior spruce have a recovery factor of plantable seedling of 36% of the seeds sown. In lodgepole pine, there is a 58% recovery factor if we use a standard seeder. In precision sowing, there is a reduction in the number of seeds used. Therefore, percent recovery has increased.

In Douglas fir the same thing is true except the gain is less radical. The difference is the number of seeds in each growing row.

Based on recommendations, seeding has taken place earlier to give the 1+0 stock as much time as possible. Previously the seeds were sown by a certain thresh-hold temperature of soil.

One of the biggest problems in bareroot spruce culture is the reoccurrence of frost heaving losses. The winter of 1980 and 1981 saw 5 million seedlings lost at Red Rock nursery alone. Use of mulches, deep cultivation, ripping of pathways, has not abated the problem that can appear in as many days as 60 in one winter. A frost heaving day is classified as a day where there is still an impervious layer of frost in the soil, a thawing condition during the day, saturated soils and freezing conditions at night. The normal amount of frost heaving days at Red Rock is 6.

The tarnish plant bug is becoming a problem. It first became apparent three years ago in the interior spruce container crop. The insect will penetrate the cambium with a long probiscus. It will cause a ceucrosis of the cambium and cause death in one part of the cambium and elongation in the other. The result is a characteristic tilt with resulting multiple tops. There has also been an increase in multiple tops in the bareroot program, especially in lodgepole pine. This insect kills the terminal meristem by the sucking action, and therefore it encourages the lateral buds to take over. A toxin is also released into the plant.

As we enter into the second year of the seedling life, we initiate our cultural practices by undercutting in the spring of the second growing season. The root manipulation program has altered greatly over the years with increasing wrenching and undercutting to develop the goal of a fibrous root system in both lodgepole pine and spruce. The current undercutting practice based on Red Rock nursery is as follows:

> Undercut 2+0 crops with a Marsh undercutter in late March or early April at the 8 or 10 inch level. Lateral pruners are used in May and every month thereafter and as the roots grow across the cut line. Commence wrenching when height has been attained in early June and continue every 10 to 14 days in opposite direction from the last wrenching. In late August and early September, undercut the crop two to three times to shape the late root growth in the zone that will remain with the plant when it is pruned after lifting to planting specifications. As can be managed, irrigation plays a vital role in this process and is used as a tool to manipulate height development. The standard summer practice when wrenching is to irrigate prior to wrenching and then to let the bed settle on its own. During extreme heat conditions, monitoring is taking place. If the plants begin to wilt, they will be irrigated. If not, 3 to 4 days later they will be irrigated.

The fibrous nature of the roots have responded very well to this practice. In addition to lateral pruning, a vertical pruner that operates at 25 degree angles from vertical has been developed over the past few years.

This is to aid in shaping the root so that a minimum of pruning is required after lifting. The results over the past two years have been very encouraging and in 1985, it is an operational practice at Red Rock.

In the coastal nurseries, the Forbro lifter has been used successfully for root wrenching during the summer season. The fingers are taken off the lifter and the wrenching is accomplished once a month to promote root growth and development in Douglas fir, pine and transplant spruce. If more wrenching is required, a conventional blade is used.

The transplant program is declining in B.C. with the advent of the 2+0 container seedling. Significant number of 1 1/2+1 1/2 and 2+1 spruce are still produced with good plantation results.

The plug transplant program has all but terminated. A field study shows a loss of typical container vigour in these plants when they are finally planted out. These plugs show outplanting characteristics of bareroot stock. The first year the plug is depressed in growth and in the second and third year shows improvement.

As with the bareroot program, various standards have been set with the container stock program. These reflect nursery capabilities and field performance characteristics. The standards are being refined with the discovery of the growing system and with the advent of site preparation.

The cultural container system in B.C. is also changing as it expands. In the seeding aspects, the soil mixing has substantially changed. The soil mixing time is shorter. It is a 4 minute mix with 6 minutes to empty the machine. The idea behind this is to prevent the breakdown of the peat fibre. The result has been better drained soils, better root mass and better air circulation.

The Vandan seeder from the U.S. has also been introduced this year. This unit is a vacuum seeder like the Vancouver biomachine, but it is a plate seeder like the shudder-box seeder. The advantage is greater accuracy upon sowing, but some seed is lost. Four to five blocks can be run through in a minute with the Vandan seeder whereas the Vancouver biomachine can handle 8

blocks per minute. With the Vancouver biomachine, one cannot inspect what you are sowing. With the plate seeder, you can look at the seed, invert the plate and drop the seed.

The B.C. nurserymen are growing their crops on a wet-dry rotation. The block weight is allowed to fall substantially before watering again. The result has been much improved irrigation and root growth.

Most nurserymen in B.C. are using slow release fertilizers. Generally, osmocote is used with a formulation of 18-6-12, but this is still augmented with soluble nutrient applications at each watering. Nutrition wise, copper still seems to be a problem and is low in some of the spruce lots. It seems to be genetically related as well. Douglas fir has shown moderate to severe needle dieback in the last three years. As yet, a nutritional link has to be found. It has been discovered that the dieback is not a pathogenic related problem. Blight is also becoming a concern in both the supplemental lighting, and in normal crop growth. In the last few years, there has been bud set in the northern part of the province where we have not seen it before. One of the reasons has been earlier sowing of the container crops and cloudy weather in April. Much more supplemental lighting is being used to prevent this. Blackout systems are very beneficial for the initiation of bud set and terminal height growth, especially in Douglas fir. Some success has also been shown in spruce, but the most common method of initiating bud set is drought stress techniques.

Facilities

In terms of greenhouses, the predominant type in B.C. is a 30 feet wide, doublepoly, steel frame house of gothic arch design, running from 160 to 200 feet long. Changes in this system include roll-down or retractable side walls for ventilation. Under-bench heating is also becoming a more common practice and there is also one installation of an infra-red heating device. Both these practices have led to better quality in the crops produced. Probably the biggest change in the greenhouse field has been the adopting by growers of computer controls for all phases of their operation. The Europeans have been doing this for a number of years and the Priva Company in B.C. has been marketing it for a few years.

Woodmere Nursery has purchased a computer developed by Walker International Computering of Sydney, B.C. The computer controls: a) all heating and ventilation systems (it controls any number of stages); b) it controls all the irrigation of the crops; c) supplemental lighting by schedules; d) fertilization injection; e) controls the filling and the heating of the water reservoir; f) in terms of data, it can also provide reports on current crop and soil temperatures, light levels, status of heaters, pumps, irrigation booms, circulation fans, log any temperature, a run time as to how long your heaters have been on and provides alarms for heating or cooling and electrical failure.

The very recent development, in terms of container systems, is the 2+0 spruce crops. This type of container is designed to meet the needs previously answered by the 2+1 bareroot transplant. Another goal is to extend the planting season into late summer, thereby putting less pressure on the already hectic spring planting season.

The basis for this stock type rests with the research work being done back as early as the 1970's where the 2+0 stock was planted along with the conventional 1+0 container stock. Ten years later this 2+0 stock type is still out-performing the 1+0 stock and definitely the 2+1 transplant material. The 2+0 term, in essence, is incorrect. These crops are sown late by 1+0 crop standards. The first year height growth for 313 container is to be kept down to about 10 cm. The crop is then overwintered outdoors and grown until bud set in the same container the next year. At this point, it is lifted up and set for planting, usually in late July or early August. The stock has gone through two growing cycles but not two full growing seasons. Problems foreseen in this system are overwintering protection in non-coastal nurseries and moss, liverwort and botrytis in the second year of development. The following solutions are suggested for the overwintering problems.

1) move the container crop in their styroblocks directly onto the soil, thus gaining the buffer of the soil;

2) select a shady, sheltered area. If an area is not available, use snow fence or something similar as a barricade, especially on the south side;

3) if available, use snow making equipment to add to existing snow levels to prevent early snow losses;

4) the use of the sono-blankets. It is a type of sponge-like polymer sheet approximately 1/4" thick. This is placed over a good blanket of snow. The idea is to prevent the snow that has already accumulated, from melting.

We extract all our container stock and grade it all. That is one of the reasons why there are fairly well established standards for cull level in B.C. The commercial contracts do stipulate that everything below their standard will be accepted.

Questions and Answers

Q. What is the reason for using refrigerated storage? You mentioned a few other things, e.g. the thermal blanket.

A. The reason for that is because B.C. has such a variety of sites. Our nursery grows for Terrace and Terrace gets its spring about 2 weeks before we do. Prince George gets spring about a week later and Peace River country gets spring about one month later. If we were to overwinter that stock at the nursery, it would be flushed. For example, by the time we sent it to Peace River sites, it would not be extractable because it would be frozen solid. Up the slopes the same thing occurs.

Q. Do you have a prescription for placing the trees in refrigerated storage? What happens between the heated greenhouse and -2°C?

A. We use very little heat in the floor. We do allow our stock to harden-off very well in October. We often leave the walls up in the greenhouse. Another factor is that we often remove the polyskins altogether during the summer and we grow under full light. Our stock will harden-off naturally in terms of the environment. Generally our container lift initiates in late October, early November.

Q. What if a grower is growing in various container sizes? Are they contracted by the 1000 or by square foot of greenhouse space or by the month or a combination of all of them?

A. They are contracted by the container size. They bid per seedling depending on the size of the container they are using.

Q. You mentioned a problem with aeration and the growing media in the containers in the 2 year container stock. What is the mix? Is it the same as the 1 year old container stock? Have you had problems with aeration?

A. No. The thing is to make sure that your first mix is very good and then we follow a wet/dry cycle to allow our soil to recharge itself with oxygen and air after each watering. In the mix, we use three peats: vermiculite, osmocote and also a mix with very low lime rates. We have moved away completely from mixing in trace elements because we found them in with our soluble fertilizers.

Q. What is the story of private growers in B.C. in both bareroot and container?

A. There are very few private growers in terms of bareroot. The rest are in container.

Q. What kind of contract do the private growers have? Is it an annual one or a long term one?

A. Most contracts are 5 year contracts, although in the spring we awarded a few 1 year contracts. They allow the individual who is successful in the bid to go to his banker and negotiate from a base price that he has to work from. The Ministry does not aid the commercial nursery sector at all aside from extension services.

Q. When is the price re-negotiated for a contract?

A. After the 5 year contract. It can be re-negotiated upward if there is a problem, but it can drop below a level.

Q. What kind of monitoring do you do with these private growers? How do you know if they are producing the kind of stock that you want to have?

A. The Ministry spends a lot of time going around to the private sector. There are a lot of extension services provided to the private sector by the ministry staff. If there are difficulties, the only source of information that they really have to turn to is the Ministry to solve the problems. In addition to that, the payment structure is such that 35% gets paid upon seeding and another 25% gets paid on the August inventory. Generally, there are once a month visits with the grower by the ministry staff. In addition to that we have four zones in B.C. nurseries: coastal, island, northern and southern interior. There is nursery organization in each one of these zones that meets three times a year: spring, summer and fall. They discuss the problems and try to resolve them.

Q. What are you doing prior to lifting, during storage, and during shipping in relation to quality control?

A. Prior to lifting, we monitor our growth so we know where we are going. We do use growth to determine our fertilizer levels. We start right at the time of seeding. We do germination studies and we establish history plots that are there right through to lifting. These we use as our fixed sample plots. We monitor them for height and caliper. One of the things we found is the more you handle the seedling, the smaller it gets. To cover ourselves, we also have a random plot. We do the same thing with containers - static and random plots. Soil sampling is done once a year. Plant sampling is also done at the end of each season. In the container program, we do a lot of work in terms of measuring the pH of our media and the conductivity of the media.

Upon lift, we have a staff checking the people as they lift and bundle. Tags are put on each bundle as they come down the sorting line so they can be identified as to who sorted the bundle. That way, random bundles can be sampled to see the quality and you can go back to that person, if there is a problem. Once they go into cold storage, there is an active monitoring system all through cold storage.

In our potting, we start immediately with root regeneration samples as it goes in the cold storage and throughout the winter to determine if there is any flux in it. We also monitor temperature and humidity. We take trees out and put them in the growth chamber and do a bud flushing assessment on them.

Q. When do you do the bud flushing?

A. We actually start doing that in about late January.

Q. Do you keep your trees in a frozen state until you ship to the Peace River district?

A. No, we don't. We turn up our cold storage about one month before the planting season begins. That means that we do store non-frozen at +1° or +2° for the last two or three months of the spring. It takes a while for the plugs to thaw out and that is why we turn the coolers up early.

Q. How much cold storage capacity do you have? Enough for all your bareroot and container?

A. Not quite. In terms of coastal B.C., a lot of stock is shipped out potted. Because of the climatic conditions, it does not really have to go to cold storage. We have gone in the province to long term leases rather than building all the cold storage ourselves. We have gone to 10 year leases for a cold storage building and in the last year alone we built another 30,000 sq. ft. of capacity in the province.

Q. What is the cost per tree in the cold storage?

A. The cost varies and it is hard to say. Where the cold storage is also used for apples, it costs us about .3 of a cent, but where the storage is designed specifically for tree seedlings, it costs up over 1 cent.

Q. The 16 to 17c cost per tree, does that include growing material, rooting medium production, extraction, overwintering and cold storage?

A. It does not include cold storage. The purchaser takes delivery of trees in the fall. For example, a nursery with the capacity of three million costs $88,000 to establish it for growing trees in styroblocks.

NEWFOUNDLAND NURSERY PRODUCTION

T. McDonough
Wooddale Provincial Nursery
Department of Forest Resources and Lands
Box 616
Grand Falls, Newfoundland
A2A 2K2

Introduction

The development of forest management in Canada's youngest Province, Newfoundland, is closely linked to the industrial development of central Newfoundland. Around the beginning of the 20th century, there was a desire to move the population from the outports to the interior area.

There were a number of timber licences issued and subsequently purchased by the pulp companies that took over, specifically, the Anglo-Newfoundland Development Company which is now Abitibi-Price. They purchased a number of renewable leases of 518,000 hectares of land of the 3.1 million hectares of actual resource land available. It has caused a problem for forest management. The companies only had one stipulation and that was that they were to manage the land towards a permanent wood supply.

It was not until 1934 that an actual forestry division was established. The main function was to take the inventory and to determine the wood usage of unalienated lands as well as inspection for logging practices and forest protection.

After entering into confederation in 1949, there was a Royal Commission established to look at what was wrong with the forestry. The Commission felt the main strengthening was required in the forest protection. Inventory needed to be looked at again and the control of domestic cutting. Domestic cutting in Newfoundland is responsible for the same use as the three pulp mills on the island now.

Establishment of nurseries

In 1938 a nursery was started near the Abitibi peninsula. The main idea was the production of growing stock for reforestation of barren areas on the eastern portion. In the establishment of the nursery, they basically cleared the area and brought in trees, a lot of them exotic species. They failed.

After a series of disastrous fires in 1961, major protection changes were taken. The province took more of a role to see that we were getting regeneration. A small nursery was opened at Mount Pearl (near St. John's) and it was on an experimental basis. They did not have much equipment and eventually no operational plantings were being taken care of. That nursery has since stopped and is now a greenhouse container production facility.

They were very particular in digging their soil pits to determine which was the best site. They dug three pits and in all three chances they hit the only areas of sand in the entire area. They started seeding immediately as soon as they started clearing the fields. They were very thoughtful and managed to remove all the top soil and took it down to the Grand Falls golf course. Broadcast seeding was done. When the workers were called away for fire duty whatever did not burn up, frost heaved. This went on for 3 or 4 years until 1977. I prefer to think of it as the year the Wooddale nursery started.

All bareroot production on the island comes from Wooddale. There is the one facility with two other container facilities - one in Mount Pearl and the other in Goose Bay. The nursery started in about 1973 in response to the budworm problems.

Newfoundlanders take everything very literally with what you say. When I came in November 1977, you could barely go down the nursery road because it was so icy. I walked into the men's lunchroom and asked one of the fellows to go with a dump truck and get a load of sand from the Department of Highways. He got back just before quitting and asked me what to do with it. I did not want it to freeze, so I told him to put it in the garage. I came back later to find 5 yards of sand sitting in the garage, no truck, just the sand.

Soil and peat

A lot of our fields have been rock picked quite extensively. We had one field that dropped one foot in elevation.

The work at Wooddale in terms of the bareroot - we have no soil testing facilities, small staff, and we have had a top to root ratio that has almost been 1+1. That is because once the soil is broken up with the peat, there is about 20% organic level. This provides a good media for root growth.

We have our own 200 acre peat bog. We have 11 fields on that peat bog that are of harvestable state. We take our own peat moss. It is screened once and is used in containers or on the field. It takes us three weeks and we can provide enough peat for the seeding process, organic amendments to all our fields and for the container operation (2 crops in 20 houses). The bog is 11 feet deep and a very fast forming bog. It is stored in containers. The moisture content of the peat is around 80%.

Seed collection

Because we are small, the best way was to start off with the collection of the seed. We have our home manufactured equipment except for the clipper-cleaner. Regular supply of seed is required, but in 1977 there was 66 lbs. of black spruce seed left. That was largely due to the budworm. The following year, we were able to get into a sprayed stand and collect some seed. If it had not been for these sprayed areas, there probably would not be any seed left.

All our collection of black spruce seed are coming from immature stands of about 15 to 22 years of age. They are selected from good sites. All the cones are picked by government employees. Our average cost of seed per pound is about $150.00. In our cold storage now, which is in the same area as the seed extraction building, we have about 1500 lbs. of black spruce seed.

Bareroot stock production

The government decided to set up production targets. They were increased from 1.4 million in 1981 to 9.5 million in 1985. Up until 1980, there was

no planting of bareroot stock on the island, other than a couple of experimental projects with the C.F.S. The field organizations were not in place to take the large number of trees that they had called for. It was rather interesting that in 1979, even though they had increased our targets we had no cold storage, one transplanter and three tractors. There was an awful lot of work to be done.

The first bareroot production was in 1980. We think they were 2+2 stock, but they were planted before I arrived, so I am not sure. Only 189,000 trees were shipped. This is what the Royal Commission thought of these trees: "The most common problem was the bushy nature of the planting stock, 50% of the stock had multiple leaders, the occurrence of multiple leaders in black sprue stock being a nursery problem, the root systems tend to be bent in the root collar area and this again caused by poor transplanting or frost heaving."

The 1+0 stage - Everything we grow in terms of bareroot on the nursery is geared towards 2+1 production. We have not ventured into 1 1/2+1 1/2. The seeding in the past has been done with a gandy seeder. Because of the rock, clay and silt composition of the ground, we do reverse mulching. We lay down an inch layer of peat, seed, and then cover the seed with sand to hold it.

We do our seeding usually in the first week of June. We actually would not get germination before July. It is a very short growing season. It is not unusual to get frost as late as June 25th. Our first attempt at fall seeding proved to be successful again because of the sand as a cover.

The layer of peat helps to prevent frost heaving. You actually see the whole bed rise and fall as the frost comes out of the ground. I think that actually promotes good root growth. Trees do not fall over and you do not tend to get a lot of J-rooting from it.

The 2+0 stock is lifted in the first or second week of November and put in cold storage. We get a two week thaw in January where you can see root growth on the trees. Our transplanting for the 2+1 ship is with the standard mechanical transplanter. There are five transplanters and two Holland transplanters that we made up ourselves.

The grading standards have essentially been borrowed from Ontario. We only have one standard right now that the tree has to be in excess of 15 cm in shoot height. We have not set any standards for root collar diameter or root area. Our water supply is Perer's River and we have standard irrigation practices.

Insects:

Around the 1960's was the beginning of the insect problems - Balsam Wooly Aphid and Hemlock Looper. Another provincial task force was established in 1973. The task force recommended to begin more intensive efforts in experimentation and in protection. Regeneration was also a problem. The trees that were coming back were not black spruce because we did not allow a fire. There was a major proportion of fir coming back and that led to the insect problem. In the early 1970's the spruce budworm was apparent. The budworm was, essentially, the reason for the establishment of the nursery in Grand Falls.

Equipment and facilities

Most of the equipment is not meant for rocky soil. One year in lifting, we went through two Egedal blades and that was only in one field. We must be getting ahead of the rocks now because the blades have lasted 4 years.

When the original plan was drawn up, it was felt that the old cold storage was sufficient for 9 million trees. We were grading in what is now the women's lunch room. It has been difficult and we have had to make a lot of changes. Now we have the main grading area and two cold storage units. We have had three offices. In the first office the floor fell out, and the second office was on top of the seed extraction building. We now have a new office.

Container stock production

The container growing production is our newest method. In 1979, we decided to go 50-50 on container and bareroot. At that time Spencer-Lemaire was chosen. We have since changed to the Can-Am multipot.

The greenhouses are double poly with oil fired heat. We multiple seed and thin later. One thing about the nursery is that it has to be very labour intensive because of the unemployment situation.

We use the spray-rite watering system as well. The booms provide our photoperiod interruption. We have two grow lux lamps on each one and they go for about 3 hours during the night.

The fertilizer rates are those used by Carlson in his publication, and we do not water unless we have fertilizer on it. We water for about an hour and a half until the trays are dripping through. This is used as a replacement method. The newest addition to Wooddale are the 20 free standing quanset greenhouses 26 feet by 96 feet.

Planting successes

Even though we do strange things, we have been able to ship stock that's flushed up to 2 inches and have no problem and fairly high success ratios. Our average plantation survival is about 93% in containers and bareroot stock after 4 years. The trees that the Commission wrote about after 4 years, were an average of 1.2 m in height and most of them established a dominant leader.

Questions and answers

Q. How about balsam fir?

A. Every bit of it should be burned. We do not grow it. It comes back so naturally and thick on the island that there is no need for it.

Q. How about white birch?

A. Yes. They look rather nice around the house. The only thing that we are producing right now is about 95% black spruce. In two years they hope to have that down to 75% black spruce and 25% white spruce in order to appease the sawmillers.

Q. With the labour problem, what kind of wages are we talking about?

A. Our average rate for a labourer is $6.66/hr. Our equipment operators are paid about $8.50/hr. There is a real interest in keeping it as labour intensive as possible. This is a very good wage for this area.

Q. Do you grow any larch?

A. We do grow some larch, but it is on experimental basis in our tree improvement program.

Q. What is your 2+1 like?

A. Our average 2+1 stock is 22 cm in terms of shoot height, weighs about 5.7 grams dry weight, and the average root area is about 60 sq. cm.

Q. Is the objective of growing 1 1/2+1 1/2 to get slightly smaller stock?

A. It was our idea to space out the transplants more. We have such a short season that we are finding it hard to get everything in, especially with the increased numbers. When I first arrived, there was the intention of growing 2+2 stock. We shipped 2+0 stock for a test plant this year and from reports it is doing fine.

Q. The peat layer is 1" thick. Is there any root penetration into the soil?

A. In the first year, the 1+0 stage, it is very minimal. At 2+0, it tends to go fairly deep into the mineral soil.

Q. How is your fertilizer regime?

A. We put a lot on. We go by colour. C.F.S. in St. John's cannot do the work for us but they would not let us go any where else to get it done. We know our soils are fairly deficient in phosphorus, so we are applying about 300 kg/ha. There is no peat put down on the transplants. The transplants are put down directly into the mineral soil.

Q. Any frost heaving?

A. Frost heaving was very prevalent until we spread the peat.

CONTAINERIZED JACK PINE GROWTH IS REDUCED ON CERTAIN PEAT TYPES

R.S. Folk and V.R. Timmer
Faculty of Forestry
University of Toronto

Introduction

The current policy for intensified forest renewal in Ontario has placed increasing dependence on container grown seedlings as planting stock. As a result, demand for container stock increased dramatically (Heeney 1983), and production capacity was expanded by involving the private sector in the task of growing seedlings. The growing regimes and cultural techniques adopted by commercial growers were highly intensive, and introduced several problems to the production process (Reffle 1985). A common problem was that crops reared under similar cultural regimes were inconsistent in size and vigour. The cause was attributed to high variability in the quality of horticultural peat used as rooting media for paper pots. This variation was evident both within and among brands offered by the manufacturers, and was suspected due to inconsistencies in physical rather than chemical or biological properties of the peats. It was hoped that a standardized grading system, or a reliable testing method for peat quality would help growers in identifying and selecting suitable peat sources.

We present here some preliminary results from a study involved in developing quality control standards for commercial peats. The approach taken was first to verify growers' experience — by rearing seedlings on different peat substrates under standard conditions and assess growth performance. Subsequently, correlations between seedling growth and the initial physical and chemical properties of the peats would be examined to isolate and identify potential indices of peat quality. This paper will deal with relationships found between seedling performance and physical characteristics of the peat sources.

Growth trials

We used jack pine as our test species, since it is an important reforestation conifer in Ontario. Seeds were sown in "mini trays" containing 34 Japanese FH 408 paperpots filled with the test media. Twenty-six different peats, obtained from a variety of retailers, private growers and Ministry nurseries in the province, were selected to ensure a diversity of types and sources of growing media having a broad range of properties. Sources originated from locations in Ontario, Quebec and the Maritime provinces. Each tray represented an experimental unit of randomized block design testing 26 peat materials, replicated 3 times. The seedlings were reared over a 16-week greenhouse rotation using a continuous feed program of commercial "starter," "regular" and "finishing" fertilizer solutions commonly used by growers. Growth development varied on the substrates. Colour differences between seedlings occurred early; reductions as much as 52% in dry weight and 37% in height (as compared to growth on best performing peat) were recorded by the end of the rotation (Table 1). The results confirmed growers' experience that crop yield was markedly effected by peat types. The next step was to test if growth reductions were associated with physical characteristics of the peat.

Physical properties of peats

Laboratory tests for physical properties were performed on samples taken from peat bags at the start of the experiment. The test samples were pre-standardized by potting and leaching for a 2-day period before analysis. The mean, range and coefficient of variation of the physical properties determined by the 26 peats are shown in Table 2. Results revealed high variation among substrates for ash content, macroporosity, bulk density, coarse:fine ratio, and saturated hydraulic conductivity (Table 2). Values for total porosity and water holding capacity exhibited a relatively low variability compared to those of macroporosity and coarse:fine ratio, probably reflecting marked differences in pore size distribution among the peats. The tests confirmed that commercially available peats have a wide range of physical properties. Despite this diversity, seedling yield correlated poorly with these routine physical measures of growing media (Table 2) accounting for only 1.0-18.5% of the observed variation in dry matter production, and suggesting that physical factors play only a minor role in controlling seedling performance.

Tolerance to physical properties

The absence of significant yield correlations for trees grown on peats with diverse physical properties could also indicate that jack pine seedlings tolerate a broad spectrum of physical characteristics. We assessed this by comparing the physical measures of a group of peats that produced seedling crops of relatively similar size. We selected the peat materials (11-24) that were ranked with a common "g" by Duncan's Multiple Range procedures in Table 1. This group represented several of the popular brands used by growers, and included the Dunmore type. The latter peat was used extensively as growing media in the early developments of container stock production at Swastika nursery, and serves as a useful reference for comparative purposes. The peat was extracted from a local muck deposit and is characterized by a relatively high bulk density, mineral content, proportion of fine particles, and considerably lower capacities for water retention and infiltration (Table 3). The better performing peats in this group ranked with the top performers of this study (Table 1).

Table 3 lists the mean values of the physical properties determined on the selected peats and their coefficients of variations. As expected differences among these substrates were large and significant; and their pattern of variability corresponded to those in Table 2. Although mean dry matter and height growth of the lowest and highest yielding seedlings raised on these peats varied only 32 and 25% respectively (Table 1), corresponding physical measures of the peat substrates differed as high 416% for ash content, 100% for coarse:fine ratio, 98% for saturated hydraulic conductivity, 73% for macroporosity, and 79% bulk density (Table 2). These large contrasts exemplify the tolerance of young jack pine to a very wide range of physical properties in rooting media used for intensive greenhouse culture.

Conclusions

These preliminary results have demonstrated that seedling growth performance can be substantially reduced on certain types of horticultural peat, but the reductions were not directly related to measured physical characteristics of the peats. Apparently containerized jack pine seedlings have the ability to tolerate a wide range of physical properties in peat growing media. Laboratory tests confirmed that peat types commonly used for

containerized tree production vary considerably in their physical properties. Furthermore, these physical criteria are not sufficiently sensitive to be used as predictors of peat quality. We surmise that the growth reductions in seedling stock are probably more closely related to chemical or biological factors of the peats, or to interactions with the fertilizer solutions. We intend to explore these associations further.

References

Carlson, L.W. 1983. Guidelines for rearing containerized conifer seedlings in Prairie Provinces. Can. For. Serv., Northern For. Res. Centre Info. Rep. NOR-X-214E.

Heeney, C.J. 1981. The status of container planting programs in Canada 5. Ontario. In: Canadian containerized tree seedling symposium. COJFRC Symposium Proc. O-P-10.

Klute, A. 1965. Laboratory measurement of hydraulic conductivity of saturated soil. In: Methods of soil analysis. C.A. Black ed. Agronomy No. 9, Madison. p. 210-220.

Reffle, R.J. 1985. Container stock production - Northern Region. In: Nurserymen's Meeting, Ontario Ministry of Natural Resources, Swastika, Kirkland Lake, June 1984. p. 1-5.

Table 1. Growth performance of jack pine seedlings raised in FH 408 paper pots filled with different peat sources

Peat No.	Brand	Dry wt (mg)	Height (cm)
1	Hillview (sphagnum)	635 a[1]	15.6 abc
2	Laurentides	620 ab	15.8 abc
3	Golden Turf (fine)	613 abc	1.9 ab
4	St. Laurent	589 abcd	16.7 a
5	Toubex (Swastika)	581 abcde	15.3 abcd
6	Artic Peat Moss	564 abcdef	14.9 abcd
7	Toubex (Thessalon)	558 abcdef	14.7 abcde
8	S-delta	551 abcdef	14.8 abcd
9	Premier (Glendon)	548 abcdef	15.0 abcd
10	Golden Turf (coarse)	543 abcdef	14.8 abcd
11	Sunshine	536 abcdefg	13.9 bcde
12	Flora	517 abcdefg	14.3 abcde
13	Premier	517 abcdefg	15.1 abcd
14	North Shore (Orono)	496 bcdefg	15.4 abcd
15	ASB (Thessalon)	489 bcdefgh	14.4 abcde
16	Garden Pride (Orono)	488 bcdefgh	14.4 abcde
17	Lambert	484 cdefgh	14.6 abcde
18	Fafard	483 cdefgh	15.2 abcd
19	Hillview	471 defgh	13.9 bcde
20	A & D	466 defgh	13.6 bcde
21	Gardenergy	461 efgh	15.1 abcd
22	Majestic	461 efgh	12.3 e
23	Fafard (Kemptville)	433 fgh	14.6 abcde
24	Donmore	406 ghi	13.0 cde
25	Blue Mountain	361 hi	13.3 cde
26	ASB (Flowermix)	304 i	12.2 e

[1] Column values not followed by the same letter are significantly different at the 5% level of probability.

Table 2. Mean, range and coefficient of variation (CV) of measured physical properties of 26 peat sources, and their linear correlatin (r) with seedling dry mass

Property	Mean	Range		CV	r
		Minimum	Maximum		
Bulk density[1] (mg/cc)	98.7	33.0	393.0	70	-0.10
Ash content[2] (%wt)	6.9	1.6	66.6	181	-0.36
Pore volume[3] (%vol)	93.8	81.6	97.8	4	0.12
Macro porosity[4] (%vol)	12.9	2.7	28.0	97	0.43
Micro porosity[5] (%vol)	76.9	66.5	86.9	8	-0.20
WHC[6] (%vol)	89.7	77.6	97.2	5	0.31
SHC[7] (cm/hr)	54.3	4.0	134.0	60	0.27
Coarse/fine ratio[8]	15.9	1.0	52.0	71	-0.27

1
2 by cylinder method
3 by combustion in muffle furnace
by calculation using bulk density, ash content and specific gravity (Carlson 1983)
4 moisture drained in 3 h after saturation
5 moisture retained in 3 h after saturation
6 water holding capacity (moisture retained at saturation)
7 by constant head method (Klute 1965)
8 weight passed or retained by 2 mm sieve

Table 3. Mean values and coefficient of variation (CV) of physical properties determined on selected peats supporting similar crop yields

Peat No.	Bulk Density (mg/cc)	Ash Content (%wt)	Macro Porosity (%vol)	WHC (%vol)	SHC cm/hr	Coarse: fine ratio
11	72 e[1]	8.9 c	11 bcd	87 abc	34 ef	39.0
12	84 d	4.3 de	18 ab	85 bc	98 a	14.6
13	82 d	1.6 f	11 bcd	87 abc	25 fg	6.1
14	50 g	3.0 ef	15 abc	96 a	64 bc	24.6
15	58 fg	3.7 def	15 bc	95 a	69 b	15.9
16	59 fg	4.4 de	22 a	90 abc	97 a	27.6
17	90 d	2.0 ef	12 bcd	90 abc	57 bc	12.9
18	59 fg	2.0 ef	10 cd	88 abc	68 bc	18.6
19	102 c	18.2 b	9 cde	91 abc	35 def	7.8
20	89 d	3.8 def	12 bc	94 ab	49 bcde	9.1
21	62 ef	5.9 d	10 cde	93 abc	48 cde	16.5
22	198 b	8.8 c	4 de	83 cd	12 g	24.5
23	68 fe	4.2 de	10 cd	89 abc	53 bcd	19.8
24	393 a	66.6 a	3 e	78 d	10 g	3.9
CV	87%	172%	43%	5%	53%	55%

[1]Column values not followed by the same letter are significantly different at the 5% level of probability (coarse:fine ratio determinations unreplicated)

HERBICIDE USE AND MONITORING

C.G. Waywell
350 Gordon Street
Guelph, Ontario
N1G 1X8

The situation concerning herbicide use in forest tree nurseries

We are now in the third year of a three-year contract agreement involving the safe use of herbicides in the provincial nurseries. This meeting is a good place to present a summary of our progress. One of the major advances is that MNR decided that there is a need for a nursery herbicide specialist and a notice of competition has been circulated to invite applications from interested individuals. I hope that the individual chosen will receive the same degree of cooperation from all of you that I have enjoyed.

Such an appointment is an acknowledgement of the importance the Ministry places on the use of herbicides to improve production efficiency. All of us are aware of the problems that weeds present and have seen the results of effective herbicide applications.

At the meeting in Indian Head, Saskatchewan last July, organized by the Canadian Forestry Service, representatives were present from most provinces from B.C. to New Brunswick as well as from New York, North and South Dakota, Montana and Alabama.

One of the most interesting topics of discussion was the cost of controlling weeds by various methods. These ranged from $7,500 to $12,000 per hectare for cultivation and hand weeding. Bruce Neil said that if they had to operate under the same conditions, as one Alberta nursery, that their budget for weed control at Indian Head would be spent in three days.

Unfortunately, weeds grow all season long. I am convinced that we must learn to use herbicides to reduce costs of production so that more trees will be available to replant the cut over areas. Along with that, however, I want to emphasize that we have to always keep in mind that too much of

the herbicides can cause other problems which may be difficult to correct. The ideal rate would be one which kills all the weed species for the whole growing season, does not affect the seedling trees, does not leave a harmful residue in the soil and does not contaminate the ground water, streams or wells. There is not any such compound, so the approach to take is to suppress or control the weed flora to reduce competition with the trees and accept a few weeds which can be controlled by hand weeding or where practical by cultivation.

Results of trials and investigations

One of the major problems encountered was that of persistent residues in the soil. In the report, I presented after visits to the seven larger nurseries, I estimated that we were losing 10 to 15% of the seedlings through improper use of herbicides.

In some situations, simazine had been used too freely in previous years. This herbicide was used for weed control in corn but was quickly replaced because it injured following crops. It tends to stay in the surface layer of soil and, since its solubility in water is 3.5 ppm at 20°C, it cannot be leached out by our normal rainfall and water applied through the irrigation system. It inhibits photosynthesis and the first symptoms of injury appear as a loss of green changing to yellow and finally brown. The root development is also retarded and the plants can be more subject to winter heaving.

Prometryne (GESAGARD) is another compound in the triazine group which has been used effectively. Much of the information available is from areas with longer growing seasons and very different climatic conditions. We have much cooler soil temperatures and shorter growing seasons and rates of application successful further south cannot be used.

In one problem case, classed at first as "winter heaving," the real cause was found to be a soil residue of prometryne high enough to retard seedling tree growth so that root development was retarded and insufficient to anchor the trees in the ground. Emergency measures taken were to use as much irrigation on the affected areas as the system allowed to prevent drying out and to leach as much as possible of the soluble material out of the root zone.

As some areas had to be used for normal planting, activated carbon was used as a slurry to dip the roots in as the seedlings were planted. This procedure has been used when planting strawberry plants in contaminated ground. The carbon adsorbs much of the soluble compounds in the soil and gives the plants a chance to develop roots. Checks throughout the remainder of the season were made and root development was normal. Soil samples have been taken over the last few years and we found that most of the prometryne stayed in the top 3 inches of the soil profile. Residues decreased from an average of 1.22 ppm in June 1983 to an average of 0.27 ppm in November 1984.

A replicated trial was established on an area at the Swastika nursery which never had prometryne applied. Soil samples were taken immediately after the prometryne applications in June and at intervals afterward. At the 1 kg/ha rate, the average of all June samples was 0.61 ppm prometryne. By October 31, the residue level was down to 0.11 ppm. This should not affect conifer seedlings.

Another problem was that in 1983 small bleached areas were noticed on conifer transplants in one compartment. At first it was thought that the injury was caused by amino triazole but the symptoms of the affected trees were not in all cases at the growing tips. A large number of the affected plants were marked with plastic tape so that they could be examined as the season progressed. The new growth was normal and the bleached areas remained the same size.

In 1984, the same type of injury was seen in several compartments including ones which had not had amino triazole applied. Samples were taken to the entomology department and to the diagnostic laboratory at Guelph. They were unable to find evidence of insect or disease injury. This supported the idea I had that the injury may have been a fertilizer burn where granules of fertilizer had lodged in the foliage and then were dissolved by dew droplets. The way to avoid this type of injury is to ensure that the seedling tops are dry before applying granular materials.

The problem of multiple leaders has been under investigation by Dr. Hofstra from Guelph. Samples were taken from several of our replicated trials at Midhurst and Swastika. There is some indication that ENIDE (diphenamid) is

implicated but the results are not clear cut as the variation within was larger than the variation between treatments.

Grass control is a major problem in some compartments. Where the grass is well above the top of the seedling trees, the use of ROUNDUP (Glyphosate) wiped on the grass foliage with a roller or "hockey stick" is successful. This is particularly effective on patches of quackgrass.

FUSILADE, and the newer FUSILADE 2000, have been used in both replicated trials and field applications. We have not observed injury on any of the conifer species and control of the grass has been satisfactory. There was some difference of opinion concerning the label so it is available this season on a temporary basis. The problem is that there is small amount of toluene and benzene in the solvent system. There is no soil residue problem according to the work reported so far.

Another experimental herbicide is in our trials this year which has been reported to be effective in the control of some of our broad leaf and grassy weeds. This is called LENTAGRAN (pyridate) which is a wettable powder with a good mammalian toxicity record and the ability to break down rapidly in the soil. My idea is that it may be used as an early post emergence application in combination with a compound-like prometryne to provide the residual effect.

Late fall germinating weed species such as checkweed, fleabane and shepherds purse are problems in many areas of Ontario. Three trials in the Swastika nursery in which different rates of ROUNDUP (glyphosate) were applied late after the trees had practically stopped growth were successful in controlling mouse ear chickweed, fleabane, shepherds purse and sedge. Counts of new growth and abnormal terminal buds were made this season on two of the trials and no differences were found on plots which had been treated with rates as high as 1 kg/ha active.

Residue analysis vs. bioassay

A serious problem is residues of herbicidally active compounds in the soil. All of us are familiar with the problem of simazine and a few others which tend to stay around too long. Residue analysis tells us what can be detected by chemical procedures. This is not always the whole picture. It is also expensive and takes time before the results are known.

Another method is to use a bioassay which simply means the use of indicator plants to give us the information we need. A simple bioassay can tell us whether there is any residue in the soil which will injure the seedling trees. The procedure is as follows:-

1. Take representative soil samples from the compartment to be checked. Make certain that some come from low lying areas where more of the herbicide may collect.

2. Mix thoroughly.

3. Put in pots or flats and when the soil is warm enough sow seeds of timothy, radish, tomato or other sensitive species in the normal way.

4. Prepare similar pots or flats using soil from an area which is known to be free of the herbicide.

5. Grow the plants in the polyhouse or greenhouse until they are 3 or 4 inches high and compare the two lots. Use several pots or flats for each compartment to ensure that the results are consistent.

6. Any abnormalities can then be noted and planting plans adjusted.

Visits to nurseries

In 1982 I had the privilege of visiting Dryden, Thunder Bay, Swastika, Midhurst, St. Williams, Orono and Kemptville nurseries. I was impressed by what you people were doing at that time to produce the trees needed.

Last year, as part of the trip to Indian Head, I was able to spend some time at Dryden. Craig White and Brian Polhill had developed a weed control programme which was most impressive. Not only were the nursery beds almost completely free of weeds in early August, but the edges of the fields and the area along the windbreaks were also practically free of weeds. As Brian said 'Well, we decided that we would not let any weeds go to seed.' That really should be the basis of reducing the weed problem.

Herbicides may seem expensive but the results are worthwhile. Labour costs will be reduced and the quality of the seedling trees will improve if everyone adopted a similar approach.

RED PINE STOCK-TYPE TESTING PROGRAM

G.D. Racey
Research Biometrician
Midhurst Research Unit
Ministry of Natural Resources
Midhurst, Ontario
L0L 1X0

A shippable seedling is a living record of all the growing conditions and stresses endured in the nursery. Its morphology and its physiological condition at the time of lifting will depend upon the cultural practices used during nursery production. Therefore, each time we significantly change our cultural practices, we produce a new stock type, which has its own set of unique properties. Currently, Ontario nurseries are producing at least four clearly defined red pine (Pinus resinosa Ait.) stock types; 2+0, 3+0, 1+2 and Japanese paper pot (FH408) container.

Past work demonstrates a definite difference in performance among stock types of red pine (Mullin 1978, Mullin 1980a,b, Mullin 1981, Racey and Hutchison 1984, Glerum and Paterson 1985). The production cost varies greatly with stock type but information on relative performance under a variety of growing conditions is limited. If all stock types perform equally well under a wide range of soil and vegetative competition then only that stock type which is the cheapest to produce should be produced. However, if some stock types outperform the others in specific tests, the attributes and cultural practices associated with the better stock should be identified and stock with those attributes produced for and planted on those specific sites.

To reach this end, we have initiated a program in 1985 of stock-type testing which evaluates relative stock type performance on a wide variety of sites in Espanola, Carleton Place and Huronia districts. Sites were selected to represent a gradient of soil types and expected vegetative competition. The stock was spring lifted and planted by regular tree

planting crews. Soil samples were taken for analyses and vegetation assessment will be done during 1985. The success of various stock types will be evaluated on the basis of survival, net height growth, relative height growth and length of time required for plantation establishment (4-6 years).

There are several key arguments which are consistently raised by nurserymen and field foresters, such as:

1. Container stock is too small and therefore, too susceptible to competition and shading or to standard herbicide treatments for controlling competition.

2. Large stock such as unwrenched 3+0 red pine should have an initial height advantage and therefore should perform better on high competition sites.

3. Transplant stock is superior to 3+0 because it is more robust and makes better short-term gains.

4. The 2+0 stock can make large gains on the 3+0 in the first year and can establish an adequate root system more quickly, therefore having an advantage on low competition sites.

5. The 2+0 is small and more susceptible to herbicides and therefore is unsuitable for sod planting.

These points will be addressed in this program and the results of these trials should reveal the role of stock size and cultural practices on field performance of red pine stock types. In addition, important information with respect to site preparation and planting prescriptions should be made available to field foresters planting specific stock types.

References

Glerum, C. and J.M. Paterson. 1985. A comparison between red pine seedlings and transplants 5 years after outplanting. Ont. Min. Nat. Resour., For. Res. Note No. 39. 4 p.

Mullin, R.E. 1978. Plantation performance averages for red pine. Ont. Min. Nat. Resour., For. Res. Note No. 16. 2 p.

Mullin, R.E. 1980a. Recent tests of seedlings versus transplants. Ont. Min. Nat. Resour., For Res. Note No. 26. 3 p.

Mullin, R.E. 1980b. Comparison of seedling and transplant performance following 15 years growth. For. Chron. 56: 231-232.

Mullin, R.E. 1981. Seedbed density effects on red pine, in the nursery and after outplanting. Ont. Min. Nat. Resour. Nursery Note 72. 5 p.

Racey, G.D. and R.E. Hutchison. 1984. A field test of 3 red pine age-classes. Ont. Min. Nat. Resour. Nursery Note 106. 5 p.

A COMPARISON BETWEEN RED PINE SEEDLINGS AND TRANSPLANTS FIVE YEARS AFTER OUTPLANTING

J.M. Paterson
Research Assistant
OTIFBI
Maple, Ontario
L0J 1E0

Nursery cultural practices change and new stock types of various species are periodically introduced. Therefore, it is necessary to test stock types regularly to determine if shifts in overall field performance occur.

One such test was initiated in 1978 when two new red pine stock types (i.e. 1+2 and 2+1) were introduced. The fifth year results of this test are reported elsewhere (Glerum and Paterson 1985), but I will highlight here some of the more pertinent observations. After all it is important to realize that when cultural practices are changed the resulting stock types will have different morphological characteristics and their physiological conditions will also have been affected.

As in other studies (Mullin and Howard 1973, Racey and Hutchison 1984) transplants appear to outperform seedling stock up to five years after outplanting. This is often the case when comparing stock from one nursery, however, when stock from two nurseries, such as Orono and Midhurst, are involved as is the case in this study, some interesting observations can be made. In this study the various stock types were outplanted at two different locations, namely Vivian Forest and Larose Forest. I will focus my comments only on the results obtained from the Vivian Forest outplanting, due to confounding effects of frost and mouse damage on the trees outplanted at Larose Forest.

The Orono 1+2 and 2+1 stock outperformed the 3+0 seedling stock both in survival and growth. However, this was not the case with the Midhurst stock, where no significant differences in survival or growth occurred between 2+2, 1+2 or 3+0 stock.

The 1+2 stock from both nurseries was smaller in initial height than the 3+0 stock but this initial height difference was overcome by the end of the third year.

Removing initial height differences, through an analysis of co-variance, and testing fifth year total height, no significant differences were found between the three Midhurst stock types or Orono 1+2 stock. The Orono 2+1 stock performed as well as Orono 2+2 stock and Orono 3+0 stock proved to be the poorest performer both in survival and growth.

Comparing the 1+2 stock produced at both nurseries, no significant differences were found in survival, annual increment or total heights. It suggests that cultural regimes used to produce this stock must have been similar.

Comparing various stock types produced at different nurseries has shown that transplants are not necessarily always better than seedling stock as shown by the Midhurst 3+0 stock. Nursery cultural practices influence the type of stock produced and its subsequent field performance greatly.

Presently work is underway to produce a 3+0 seedling with transplant characteristics through a process of root pruning and wrenching. This practice shows promise and the new 3+0 stock will not be like the 3+0 stock which was tested in this study. This new stock type is expected to perform better when outplanted than its predecessor.

References

Glerum, C. and J.M. Paterson. 1985. A comparison between red pine seedlings and transplants five years after outplanting. Ont. Min. Nat. Resour., For. Res. Note No. 39. 4 p.

Mullin, R.E. and C.P. Howard. 1973. Transplants do better than seedlings and... For. Chron. 49(5): 213-218.

Racey, G.D. and R.E. Hutchison. 1984. A field test of 3 red pine age classes. Ont. Min. Nat. Resour., Nursery Note No. 106. 5 p.

Table 1. Ranking of several red pine stock types by fifth year average height adjusted for initial height using an analysis of co-variance*, stock is from two nurseries and planted at Vivian Forest

Ranking	Stock type	Percent Survival	Adjusted average 5th year height* (cm)
1	1 + 2 MIDHURST	93	118.9a
2	2 + 2 MIDHURST	89	116.1a
3	1 + 2 ORONO	89	114.7a
4	3 + 0 MIDHURST	91	110.0a
5	2 + 1 ORONO	72	99.6b
6	2 + 2 ORONO	80	98.9b
7	3 + 0 ORONO	67	92.5c

*Height figures in the columns not followed by the same letter, differ significantly from each other at the 1.0% level.

CONDITIONS OF RED OAK NURSERY STOCK AS RELATED TO OUTPLANTING

G. Stroempl
Silviculturist
OTIFBI
Maple, Ontario
LOJ 1E0

The total production of hardwood stock, excluding poplar, in the MNR nurseries is about 3%. Red oak, one of the most sought species, constitutes an average annual production of 335,000. Even this small amount requires effort and money to meet the target.

In the northern mixedwood and hardwood cover types of Ontario's forests, 50% of the productive forest land, red oak rates as one of the major species. The relatively large supplies of oak, and other valuable hardwoods, have quickly diminished through overcutting, and it will take several generations to replenish the quantity necessary to satisfy the domestic demand. Red oak is one of the 8 hardwood species of higher value than sugar maple, 34% more (OMNR, 1981). Ontario is importing veneer logs of red and white oaks, along with yellow birch and sugar maple (Nevel et al., 1982). Good growth, high quality and high market value make red oak a desirable species for a great variety of products. Some industries depend on good quality oak what justifies to promote the regeneration and growing of oak in southern Ontario.

Regenerating oak naturally or by planting requires a high degree of silvicultural expertise. First efforts are underway in the Algonquin Region to plant oak nursery stock after shelterwood and strip cuttings in hardwood forests (Gordon, 1985). To do this successfully, certain conditions of the stock must be met to maximize the chances of survival and growth after outplanting.

1. Bud dormancy. There is a time period of up to 3 weeks between the planting readiness of the stock and the actual time of outplanting. The problem facing the planter is how to avoid breaking off the fragile terminal buds during the process of handling and planting that are often swollen, flushed or even have elongated into shoots.

A simple remedy is to cover with burlap sack the bundles of the heeled-in stock in the nursery beds to exclude light and heat, thus retarding growth activity. Or, the bundles should be tightly packaged and cold-stored until shipping, with the roots surrounded by moist peat moss to prevent drying out (Webb and von Althen, 1980).

Another alternative is to encourage the Forest Districts to pick up their stock as soon as it is shippable and store them indoors or outdoors, particularly in the Districts where snow may still be available and can be used effectively as a cooling medium.

2. Root system. Another problem with red oak, and other hardwood stock, is the large volume of roots difficult to keep moist during storage and even more difficult to plant. This often results in squeezing a large volume of roots into a too small planting hole.

It is absolutely essential that the roots are cut to a predetermined length (Stroempl, 1985) to facilitate packaging, storing and planting, thus maximize the root regenerating potential immediately after outplanting (Kozlowski, 1976).

3. Quality grading. Planting success of red oak nursery stock can be further improved by morphological grading based on relatively easily observable criteria. A system of grading based on stem diameter, height, stem form, buds and roots, is suggested and described in a Research Note (Stroempl, 1985).

References

Gordon, A.M. 1985. Maintaining a red oak component in the hardwood forests of southern Ontario. Univ. Guelph, Ont. 28 p. (Proposal to The Ontario Renewable Resource Research Fund Grant Program).

Kozlowski, T.T. 1976. Drought and transplantability of trees. Symposium Proceed. USDA Tech. Rep. NE-22. pp. 77-90.

Nevel, R.L. Jr., E.L. Stochia, T. Wahl. 1982. New York Timber Industries - a periodic assessment of timber output. USDA Resource Bull. NE-73. 30 p.

Ontario Ministry of Natural Resources. 1981. Statistics 1981. Toronto, Ont. 125 p.

Stroempl, G. 1985. Grading northern red oak planting stock. Tree Planters' Notes 36:15-18.

Webb, D.P. and F.W. von Althen. 1980. Storage of hardwood planting stock; Effects of various storage regimes and packaging methods on root growth an physiological quality. New Zealand Jour. For. Sci. 10:83-96

Reprinted from Tree Planters' Notes, Vol. 36, No. 1
Pages 15-18 Winter 1985

Grading Northern Red Oak Planting Stock

G. Stroempl

Research scientist, Ontario Tree Improvement and Forest Biomass Institute, Maple, ON, Canada.

A system for morphological grading of red oak nursery stock, based on stem diameter and length, stem form, buds and roots, is described.

During planting experiments from 1976 to 1982 (*11*), some 16,000 northern red oak (*Quercus rubra* L.) seedlings, mostly 2+0 nursery stock, were graded to obtain uniform size and form. The trees were supplied by the nurseries of the Ontario Ministry of Natural Resources. About 40 percent of these in any 1 year of planting were of unacceptable quality. On a provincial scale, this would represent an average of 134,000 of the 336,500 seedlings produced each year in ministry nurseries (*9*). It became apparent that morphological grading of planting stock would be necessary in addition to the rather minimal standards for planting stock size, as recommended for average sites in Ontario (*12*). Procuring acorns from local trees with desired phenotypic characteristics (*5, 6*) should also be a minimal practice in hardwood tree improvement programs. It is the purpose here to suggest improved grading standards for red oak to be used in field plantings in southern Ontario.

The grading criteria are based on root-collar diameter and stem length (table 1) and stem form, bud number, and roots of large and small 2+0 nursery stock (figs. 1 and 2). Stock should be graded in nurseries before bundling or on a planting site to avoid the cost of planting inferior stock, which will perform poorly.

Table 1—*Provisional root-collar diameter and stem length grades for 2+0 red oak nursery stock*

Seedling size	Root-collar diameter (mm)	Stem length (cm)
Large	7.5-8.5	55-75
Small	4.5-6.5	30-45
Cull	< 4.5	—

Stem Diameter and Stem Length

Stem diameter and stem length are the criteria with the greatest variations among nurseries, years, and seed sources and should be the basis for judging quality of planting stock (*8, 14*). In Ontario plantings, root-collar diameter and stem length were reliable indicators of relative growth potential regardless of age of stock (*12*). A caliper of 8 millimeters, measured 2 centimeters above the root-collar, and a shoot length from 50 centimeters to 1 meter have been recommended for red oak (*3,4*).

I have observed in numerous plantations that rabbits tend to clip plants of about 6.5 millimeters stem diameter or less often to ground level, leaving a stump that seldom resprouts because it has no dormant buds. This is usually the case with 1+0 nursery stock of small root-collar diameter. Larger diameter stock, however, is seldom clipped to the ground level, and dormant buds are left along the lower stem and near the root-collar, thus allowing resprouting. When clipped seedling stock resprouts, the growth of the sprout will be more vigorous on larger diameter stumps than on smaller ones.

Stem Form

The stem should be well defined and straight, with relatively short branches on the previous year's growth. Long branches (fig. 1, sample 5) should be pruned and multiple leading shoots should be pruned to leave the sturdiest shoot (fig. 2, sample 6) on seedlings that have met all other criteria. I have observed that thin whip-like long stems (fig. 1, sample 6; fig. 2, samples 7 and 8) usually grow very slowly. Seedlings with multiple stems should be culled and the sources of acorns that do poorly identified (*7*).

Buds

The stem should have numerous buds, especially on the last year's growth, and a cluster of buds at the apex. Buds should not be swollen or flushed at the time of planting. Acorns from more southerly sources tend to produce seedlings that flush early

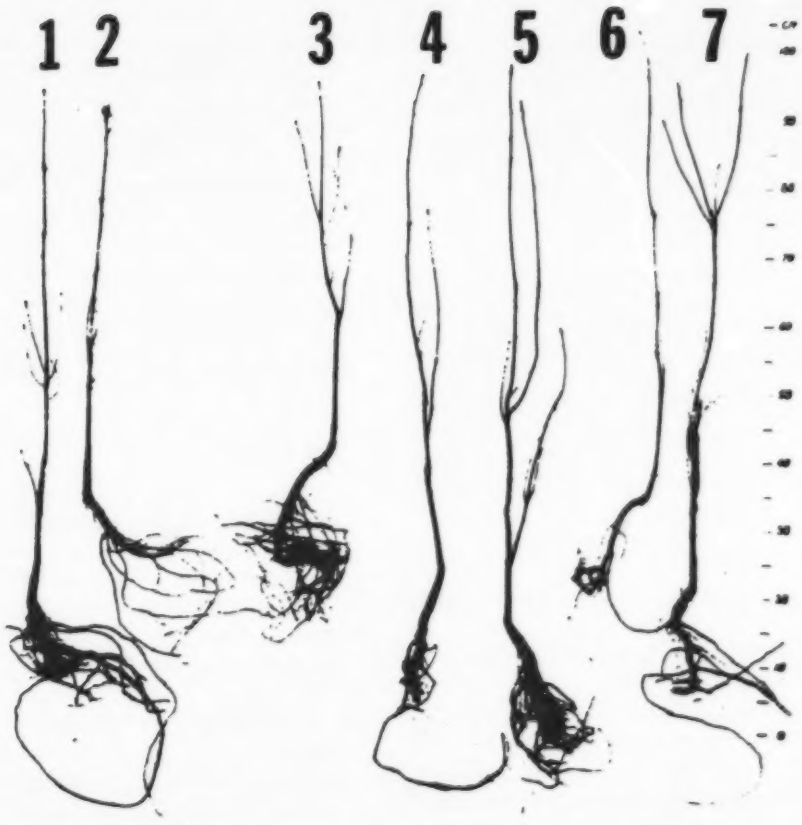

Figure 1—*Large 2+0 nursery stock of northern red oak after lifting.*
***Class 1**—Seedlings 1 and 2 (acceptable). Leading shoot is well defined, sturdy, and straight with buds on most of stem. Branches are relatively short, mainly on previous year's growth.*
***Class 2**—Seedling 3 (acceptable). Leading shoot less defined and less sturdy than grade 1 with fewer buds and more prominent branches.*
***Class 3**—Seedings 4 and 5 (acceptable). Leading shoot is thin or forked with prominent branches. Large root-collar diameter ensures resprouting when stem is decapitated or injured due to browsing or girdling. Prune branches, particularly the upper branch on 5.*
***Class 4**—Seedlings on 6 and 7 (culls). Stem is very thin with questionable resprouting capacity when decapitated or injured and/or tendency to forking prominent.*
***Root pruning.** Tap root should be pruned to 20 to 25 centimeters length and lateral roots to 10 to 15 centimeters length (to facilitate spreading out roots in planting hole).*

and are thus more susceptible to frost damage. An important and consistent difference between geographic sources in red oak has been found in the dormancy requirements (*7, 13*).

Roots

Undercutting of roots before seedlings are lifted from the nursery beds shortens the tap root, often resulting in a "hockey stick" root but leaving most of the lateral roots up to 1 meter long intact. Although this undercutting may not affect the vigor of a young tree, the weight of the developing crown cannot be properly supported and mechanical damage to the roots may result after outplanting, as found in several coniferous species (*2*). In addition, such bent roots may be more susceptible to root rot, as found in planted white spruce (*10*). Because seedlings develop new roots soon after planting, additional pruning of lateral roots is good practice to prevent long roots from being placed close to the surface of a conventional planting hole. Pruning to about 20 to 25 centimeters is therefore recommended for red oak to facilitate field planting and ensure a high rate of survival (*4, 6*).

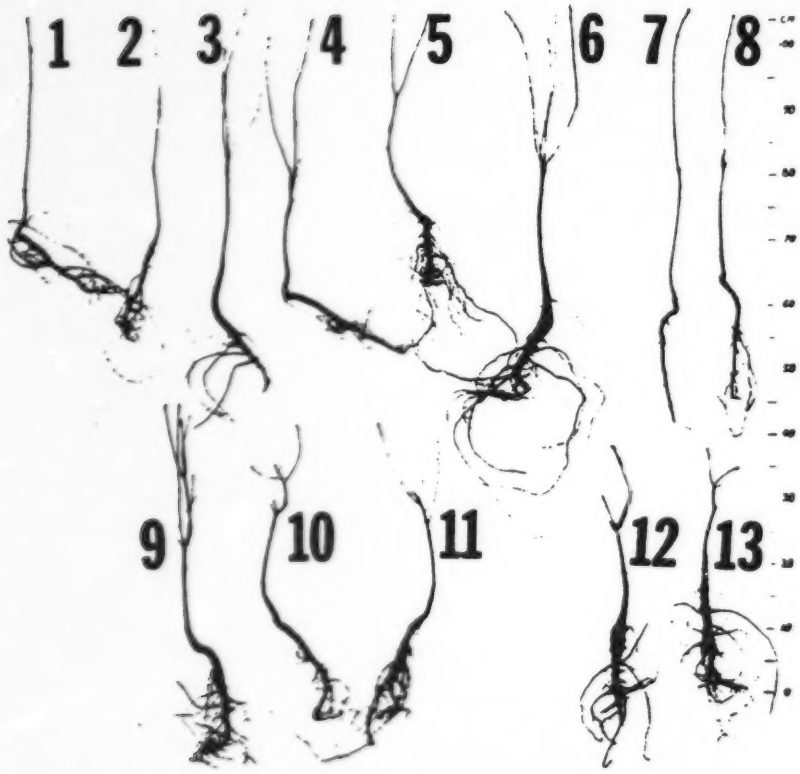

Figure 2—*Small 2+0 nursery stock of northern red oak after lifting.*
Class 1—*Seedling 1 (acceptable). Leading shoot sturdy, straight with buds on most of stem. Branches usually absent.*
Class 2—*Seedlings 2 and 3 (acceptable). Leading shoot less sturdy than grade 1. Branches sometimes relatively too long as in 3.*
Class 3—*Seedlings 4 to 6 (acceptable). Stem with 2 to 3 leading shoots. Ensure presence of terminal buds on the sturdiest shoot and prune the remaining ones.*
Class 4—*Seedlings 7 to 13 (culls). Stem of poor form, very thin, tendency to forking prominent.*
Root pruning. *Tap root should be pruned to 15 centimeters length and lateral roots to 10 centimeters length (to facilitate spreading out roots in planting hole).*

Conclusion

Red oak nursery stock can be graded by assessing relatively easily observable criteria. Stock of better quality should improve the performance of red oak plantations in Ontario. This should also strengthen the confidence in propagating oak where it grows faster and is of better quality than, for example, sugar maple (*1*). Use of acorns from selected local phenotypes should also be a standard practice to maximize propagation of sources with rapid juvenile growth and other important characteristics.

Literature Cited

1. Arend, J.L., Scholz, H.F. Oak forests of the Lake States and their management. Res. Pap. NC-31. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 36 p, 1969.
2. Buckland, D.C. Observations on *Armillaria mellea* in immature Douglas fir. Forestry Chronicle 29: 344–347, 1953.
3. Foster, A.A.; Farmer, Jr., R.E. Juvenile growth of planted northern red oak: effects of fertilization and size of planting stock. Tree Planters' Notes 21: 4–7, 1970.
4. Johnson, P.S. Nursery stock requirements for oak planting in upland forests. In: Proc. Northeastern area nurserymen's conference, 1981, Springfield, MO. Jefferson City: Missouri Department of Conservation; 1981. p. 2–19.
5. Kriebel, H.B.; Bagley, W.T.; Deneke, F.J.; Frunsch, R.W.; Roth, P.; Jokela, J.J.; Merritt, C.; Wright, J.W.; Williams, R.D. Geographic variation in *Quercus rubra* in North Central United States plantations. Silvae Genetica 25: 118–122, 1975.
6. Larson, M.M.; Whitmore, F.W. Moisture stress affects root regeneration and early growth of red oak seedlings. Forest Science 16: 495–498; 1970.
7. McGee, C.E. Elevation of seed sources and planting sites affects phenology and development of red oak seedlings. Forest Science 20: 160–164; 1974.
8. Olson, D.F.; Hooper, R.M. Northern red oak plantings survive well in southern Appalachians. Tree Planters' Notes 23: 16–18; 1972.
9. Ontario Ministry of Natural Resources. Statistics. Toronto, ON: 1981. 126 p.
10. Oullette, G.B.; Bard, G.; Cauchon, R. Self strangulation of roots: joints of entry of root rot fungi in Grand Mere white spruce plantations. Phytoprotection 52: 119–124; 1971.
11. Stroempl, G. Forest Research 1981–1982. p. 25–26. Maple, ON: Ontario Ministry of Natural Resources, 1982.
12. Von Aithen, F.W. Proposed planting stock grades for hardwoods planted in Ontario. Inf. Rep. 0-X-106. Sault Ste. Maire, ON: Canadian Forest Service, 9 p.
13. Webb, C.D. Genetics and tree improvement in the oak-yellow-poplar type. In: The silviculture of oaks and associated species. Res. Pap. NE-144. Broomall, PA: U.S. Department of Agriculture Forest Service, Northeastern Forest Experiment Station; p. 57–65. 1970.
14. Wendel, G.W. Growth and survival of planted northern red oak seedlings in West Virginia. Southern Journal of Forest Science 10: 83-96; 1980. ■

GREENHOUSE TRANSPLANTS -- LANNEN'S PAPERPOTS

S.T. (Susan) Griffiths
Technical Sales Representative
Hakmet Ltd.
690 Progress Avenue, Unit 3
Scarborough, Ontario
M1H 3A8

Introduction

Small diameter paperpots are used for the production of tree seedlings. Hopefully, it will replace the old system of bareroot transplants.

Types of paperpots

The tree seedlings can be grown in either the BS 105 or 205 (1 cm or 2 cm diameter pots and 5 cm in depth). The paperpot set fits into a 40 cm x 60 cm tray size. The container is made of a "B" quality of paper, which takes roughly, up to 8 weeks to decompose.

The ecopot comes in a 35 cm x 94 cm tray size and, also, a 40 cm x 60 cm tray size. The ecopot 408, which fits into the MNR tray size, has 345 pots/set.

The Ecopot is a new pot type, suitable for growing tree seedlings that will be grown for one or more seasons. The pots are made of plastic laminated paper strips that are glued together in rows. The paper decomposes during propagation period and leaves only the plastic walls around the container. The plastic is then stripped off before planting.

Advantages of paperpots

Some of the advantages of the BS 105 paperpots are: high production, high seedling density in the greenhouse at 353 trees per sq. ft., better utilization of greenhouse space, and less seed is required. Also, you have a well positioned plant without any thinning. The tree seedlings are fast at establishing a good root system after transplanting. It is a flexible

system. Production levels can be easily adjusted and it fits in well with existing tree nurseries that are presently using the paperpot system.

The main advantage of the ecopots is in planting containerless tree seedlings. The root system is well branched and holds a compact container together. The design of the ecopot prevents roots from coiling-up therefore the seedling establishes roots in the soil immediately.

Another advantage is that the Lannen paperpot greenhouse equipment, such as the filling and seeding, can also be used with ecopot system.

Growing stage

In the initial growth stage it requires air pruning in order to make sure that the plants will root well after transplanting. It is also easier to separate the individual pots. Special attention should be paid to the fertilization requirements because there is a larger proportion of paper walls in small pots as compared to the larger pots, and this is especially true for the BS 105. More nitrogen is required at the beginning due to nitrogen fixation. BS 105 decomposes a lot slower than the BS 205.

Trials

Last July the Canadian Forest Service in Sault Ste. Marie grew some tree seedlings in both the BS 105 and 205 paperpots. The following September the paperpots were transplanted in the nursery at Thessalon.

This year, Thessalon will be conducting a larger operational trial of growing both the BS 105 and 205. The paperpots, twelve weeks old, will be transplanted with a four-row transplanting unit at the end of July.

Transplanting

A semi-automatic tractor-drawn transplanter, consisting of six planting units, has been designed to plant the small paperpot containers. It can plant up to, approximately, 150,000 tree seedlings per day. The minimum row spacing is 12.5 cm and the distance between seedlings is 6 to 7 cm, and can be adjusted at 1 cm intervals.

The transplanter can have a maximum of six units. The number of people required for a six unit planter is eight: six planting, one driving the tractor and one handling the trees.

Both the Swastika nursery and a private tree nursery have been trying out the ecopot. This system has been gaining in popularity in Scandinavia. In 1984, over there 50 million trees were grown in the ecopot. They plan to increase their production in 1985 to 100 million ecopots.

Questions and Answers

Q. What is the cost of the transplanter?

A. For the two-row, it is about $4,000.

Q. What do you fertilize with? Mostly nitrogen?

A. Multinutrient fertilizers are used in Finland as a complete fertilizer for both peatmoss base fertilizer and raising fertilizer. Their main nourishment ratio is N:P:K=3:1:3, in addition to which they have micro nutrients. Additional nitrogen is given as calcium-ammonium-saltpeter after germination. Application is done 2-3 times for BS 105 seedlings and 1-2 times for BS 205 seedlings.

Q. How about phosphorus and potassium?

A. No additional phosphorus or potassium is necessary when using the above regime.

Q. Could you perhaps elaborate on the paper quality? After we tried a new Finnish material, there did not seem to be large differences. Can you update us on that please? Is it the same type of paper used in the new ones here?

A. The quality of Finnish and Japanese pots should be nearly the same. The elements affecting the decomposition of paperpots is heat and moisture, which provide the ideal conditions for growing micro-organisms, and

breakdown of the paper. Nitrogen also has an indirect effect. It at first binds with microbes, but is later released to be utilized by seedlings. Also the degree of acidity of the soil (pH) has a slight effect.

Q. Is there a relationship between the amount of nitrogen and the rate of decomposition?

A. The supplementary nitrogen ensures that seedlings have an adequate amount of nitrogen. The faster the paperpot decomposes, the more nitrogen is bound to it, and it is therefore not available for use by the seedlings.

Q. When you shift to a new technique of culturing, it would be nice for the growers to know if they have to change their formulations?

A. When we have more information about types of fertilizers in use and their applications, we can provide more detailed advise on fertilization.

Q. Is this system being used in Quebec?

A. No.

Q. Is there only one machine in Canada?

A. Yes, just one planting unit in Canada and it is at Thessalon.

Q. After the 12 week growing period, do the roots start to intergrow from pot to pot?

A. The roots on Scotch pine start growing through the walls 4-6 weeks after germination, depending on the growing method. Generally, Scotch pine cannot be grown in BS-type pots for longer than 8-10 weeks. The roots on Norway spruce develop slower and form more rootlets. A raising period of 10-12 weeks has been feasible without notable difficulties.

Q. Do they transplant in the fall or from the frozen storage in the spring?

A. They transplant in late August - early fall.

Q. Are you talking about Scotch pine only or are you, also, talking about Norway spruce?

A. Well, this is what is being used in Finland. They are using Scotch pine and Norway spruce.

TREE IMPROVEMENT

J.V. Hood
Geneticist
Tree Seed and Forest Genetics Unit
Forest Resources Branch
Ministry of Natural Resources
Whitney Block
99 Wellesley Street West
Toronto, Ontario
M7A 1W3

Introduction

This presentation concerns the role of the nursery in the Provincial tree improvement program. As the tree improvement program expands, so, too, will the role of Ontario's tree nurseries.

Until 1980, the nurseries served two main functions with respect to the tree improvement program: grafting was done for the three clonal seed orchards in existence at the time and special stock was grown to serve the needs of tree breeders at Maple and Petawawa. In the later 1970s, Orono Nursery began its work on the development of a juvenile cutting system.

Further expansion of the nursery's role has been evidenced in recent years. The role now includes grafting for the establishment of breeding orchards, nursery stock production for seedling seed orchards and family test establishment, and, as mentioned above, special needs. With the commencement of these additional activities comes a demand for top-quality products and meticulous, detailed record-keeping.

Even greater involvement by the nurseries is inevitable as the Provincial tree improvement program matures. Developments in vegetative propagation for the clonal forestry option, controlled-environment breeding orchards, and specialized nursery production systems will necessitate this

involvement. Some new programs have already been initiated along the lines of breeding halls; in particular, Swastika nursery has tried some flower induction work.

Nurseries are evolving from a pure production role to one more similar to a technology development unit and working on problem areas that will be important to tree improvement programs.

What, then, may be the expected role of the nurseries in the future? It is predicted that the role will be comprised of three functions complementing the Provincial tree improvement program.

1. The nurseries will continue to produce materials for the tree improvement program, but at an expanded level. Grafting will become an increasing activity as more clonal seed orchards are established for first- and second-generation improvement. Nurseries will continue to produce stock for seedling seed orchards and associated family tests. Seedlings grown from control-pollinated seeds will be used for progeny-testing the first-generation seed orchards. All this is in addition to the production of stock for forest management programs.

2. Production of plantation material for commercial use will continue as a major function of the nurseries. It is hoped that more of the seedlings grown by the nurseries in the future will be of the container variety. It is important that genetically-improved seeds be sown in containers because of the better seed-to-shippable-seedling ratio over bareroot production. Cost-benefit analyses undertaken by the Tree Seed and Forest Genetics Unit demonstrate the advantages, both economically and biologically, of using genetically-improved seeds wisely and efficiently through container production.

   You may be interested to know that forest geneticists are doing something to ease the nurseryman's task although it may not be obvious from the preceding discussion. Greater uniformity among the seedling crops will be obtained as the nurseries sow more genetically-tested, improved seeds. This will, at least, reduce some of the problems in culling, sorting, packaging, etc.

Rooted cuttings will become more prevalent throughout the province and will be used to supplement shortages of seedlings and may eventually become the main source of material for our plantations.

Work to improve the rootability of cuttings through juvenility-induction will be carried out at the nurseries. There has to be continuous development of the vegetative propagation system so that problems in maturation can be resolved - as a plant gets older it is much more difficult to obtain cuttings that will root readily. Progress in this area will permit tree breeders to take full advantage of the types of genetic gains that are available.

Donor stock for the rooted cutting program is expected to be grown primarily from seed orchard and breeding orchard seeds. However, progress in tissue culture research may become an important source for cuttings and would add a whole new dimension to the nursery's involvement in tree improvement work.

3. Apparent from the preceding discussion, nurseries will be intimately involved in research and development work. In addition to their work with rooting of cuttings and tissue culturing, nurseries will help with the development of breeding orchard technology to promote and enhance early flowering. Advances in flower induction will hasten breeding work, progeny testing, and subsequent establishment of advanced-generation seed orchards.

Conclusion

As outlined, the nurseries will be required to play a greater role in the provincial tree improvement program through production of tree improvement material, production of plantation material, and development work. Nurserymen and tree breeders must work together to meet the demands for better trees for the future.

Questions and Answers

Q. I don't know a lot about other regions, but I know a little about central region. I don't see the field foresters clamouring for this

improved stock. The demand that we get at the nursery should include rooted cuttings, grafts and so on for field planting and at this state, even test planting. Whenever you mention it, it falls like dead thud. Somewhere in there I think you have to have some kind of demonstration program to get some of this information out to show field personnel what can happen.

A. This is one of the reasons that we plant trees and is one of the reasons you put tests out there.

Q. The demonstration right now is for research people. There has not been anything created for the regular tree planters to show some desire in these improved trees.

A. It's a catch 22 situation.

Comment:

In the central region we have had a tree breeding room at Maple for a long time, a centre at Orono which is half empty, so it should be the central region that wants these improvements.

Q. In the central region how much Crown land do we have to plant?

A. It's not a matter of whether it is Crown or private, but a matter of how many trees this region puts in the ground.

Q. Can I suggest that you select for root regeneration potential rather than for growth. Are you looking for root vigour in the early stages?

A. I believe there are some projects - black spruce particularly. Black spruce is a good root regenerator. You don't have too many problems. Genetic improvement is needed in white spruce.

Comment:

I would like to say two things about tree improvement - the genetic potential of an organism and how that genetic potential is expressed in the environment. Silviculture is essentially trying to manipulate that

environment. It makes sense to go with the best set of genes that we can. Tree improvement is a long term process. Although you may not see it right now, we have a lot of silvicultural problems.

Q. Can you give us an idea on the kind of gain you are going to get. We get figures from fertilization. Can you give us a value on the work you are doing now - what kind of gain do you expect?

A. Well, in a sense you get broad adaptability as a selection tool when you put your test out there.

Comment:
We would like to see you select for other criteria - root regeneration and frost hardiness in white spruce. We are not worried about a 10% increase in growth. You might get it with those two characteristics.

Comment:
There is a lot of criteria that we can look at depending on how many physiologists we can get to work on it. One of the major road blocks in tree improvement is the early testing - a method of evaluation of seedling or juvenile plants that will accurately predict their performance when they are adults. Also, there are a number of physiological traits that are, possibly, good key indicators of future performance.

There is natural selection going on out there and sometimes it works for you and so when you have selected this biggest tree, you have selected a tree that may have been subjected to a number environmental factors. Things can be looked at in the lab if there is the financial backing behind it.

Appendix 1

AGENDA

MONDAY, June 24th, 1985

18:30 - 21:00 Registration
19:00 - 23:00 Mini Trade Show and Ice Breaker

TUESDAY, June 25th

08:30 Opening Remarks ..... Glenn McLeod
08:45 Orono Fertility Trials ..... Bill Bunting
09:30 Effective Fertilization of Nursery Crops ..... Vic Timmer
10:00 Coffee
10:15 Root Pruning and Wrenching ..... Alf Campbell
10:45 Mulching Trials ..... Gerry Racey
11:15 Dormancy Induction and Testing ..... Gerry Hofstra
11:45 Lunch
13:15 Hand Held Data Entry Devices ..... Don MacIver
13:45 B.C. Nursery Production ..... Clare Kooistra
14:45 Coffee
15:10 Maritime Nursery Production ..... Tom McDonough
16:10 Adjourn
17:10 Bus leaves for Ganaraska Forest
18:15 Barbeque

WEDNESDAY, June 26th

Indoor Session

08:30 MNR Contract Reports (verbal only)
08:30 Soil Monitoring: Glendon Hall ..... Vic Timmer
09:00 Soil Moisture Monitoring ..... Bill Bunting
09:30 Ship Quality Monitoring ..... Bob Day
10:00 Coffee
10:15 Herbicide Use and Monitoring ..... Charlie Waywell
10:45 Site/Age Class Trials with Red Pine ..... Gerry Racey
11:00 A comparison Between Red Pine Seedlings and Transplants Five Years After Outplanting ..... John Paterson
11:15 Tree Planting Guidelines and Certification ... George Stroempl
11:45 Lunch
13:00 Greenhouse Transplants ..... Sue Griffiths
13:45 Bus leaves for Weall & Cullen Nurseries ..... Bob Lennie
18:15 Bus returns to Flying Dutchman Hotel

19:00 - 21:00 Brag and Boast Session

Operational Session

08:30 Bus leaves for Orono Nursery
09:00 Tilage ..... Niel Moore
10:30 Coffee
10:45 Sprayers and Spray Monitors Demonstration ..... Bob Trimble
11:30 Tractor Demonstration ..... Bob Nixon
12:00 Lunch
13:00 Seeding Information Exchange ..... All Nurseries
14:30 Coffee
14:45 Tour of Jensens Greenhouses
16:00 Bus return to Flying Dutchman Hotel

19:00 - 21:00 Brag and Boast Session (verbal only)
Thessalon (Eleanor LaPorte) - fertility
Kemptville (Pam Smith) - computers
Swastika (Clave Mahonen) - tree harvester
Midhurst (Ken Reese) - Pw lifting in hot weather
Research (variety) - the untold story

THURSDAY, June 27th

08:30 Bus departs from Flying Dutchman Hotel
08:45 Tour of Orono Nursery
10:15 Coffee
10:30 Tour of Orono Nursery
12:00 Lunch - Orono Arena
13:15 Forest Management (verbal only) ..... John Broderick
13:45 Tree Improvement ..... Jim Hood
14:15 Housekeeping Items ..... Ron Reffle
14:45 Adjourn

Appendix 2

ATTENDANCE

Name	Location
AMOS, Chris	Orono
ARMSTRONG, Guy	University of Toronto
BILLINGS, Raoul	Chapleau Tree Nursery
BLACK, Wally	Midhurst Tree Nursery
BORCZON, Ed	Central Region, Richmond Hill
BOUFFORD, Don	Orono Tree Nursery
BUNTING, Bill	Orono
CAMPBELL, Alf	Kemptville Tree Nursery
CARLETON, John	Chapleau Tree Nursery
CHONG, Nancy	Pest Control Section, Maple
CLARK, Lorne	Petawawa National Forest Institute
COMEAU, Al	Kemptville Tree Nursery
CRAWFORD, Randy	Midhurst Tree Nursery
CREASEY, Kim	Tree Seed Plant
CRICH, Mel	Midhurst Tree Nursery
DAVIES, Gary	Thunder Bay Tree Nursery
DAY, Bob	Lakehead University
deVRIES, Henk	Eastern Region, Kemptville
ENG, Ken	Central Region, Richmond Hill
GOWER, William	Gogama Tree Nursery
HILLS, Carl	Somerville Tree Nursery
HOFSTRA, Gerry	University of Guelph
HUISMAN, Tjerk	Gogama Tree Nursery
HUTCHISON, Bob	Midhurst Research Unit
JARVIS, Scott	Swastika Tree Nursery
JUZWIK, Jennifer	Pest Control Section, Maple
KAY, Linda	Pest Control Section, Maple
KIMMETT, Carl	Sir Sandford Fleming College, Lindsay
KLAPPRAT, Bob	Thunder Bay Tree Nursery
KOOISTRA, Clare	British Columbia
LAMBERT, Rick	Main Office, Toronto

LAPORTE, Eleanor	Thessalon Tree Nursery
LEEDER, Grant	Kemptville Tree Nursery
MACIVER, Don	Main Office, Toronto
MACMILLAN, Doug	Swastika Tree Nursery
MACNAUGHTAN, David	Kemptville Tree Nursery
MAHONEN, Clave	Swastika Tree Nursery
MALONEY, Kevin	Thessalon Tree Nursery
MANSFIELD, Carl	Midhurst Tree Nursery
MCDONOUGH, Tom	Wooddale Provincial Tree Nursery, Newfoundland
MCINTYRE, Malcolm	Dryden Tree Nursery
MCLEOD, Glenn	Orono Tree Nursery
MILLER, Ian	Petawawa National Forest Institute
MOORE, Dave	Orono Tree Nursery
MYLAND, Terry	Dryden Tree Nursery
PATCHELL, Ed	Thunder Bay Tree Nursery
PATERSON, John	OTIFBI, Maple
PATERSON, Lorna	Orono
PFEFFER, Lloyd	Orono Tree Nursery
PHILLION, Bernie	Thunder Bay Tree Nursery
POLHILL, Brian	Dryden Tree Nursery
POSTMA, Mike	St. Williams Tree Nursery
RACEY, Gerry	Midhurst Research Unit
REESE, Ken	Midhurst Tree Nursery
REFFLE, Ron	Main Office, Toronto
ROBERTSON, Don	St. Williams Tree Nursery
SADREIKA, Vic	Main Office, Toronto
SANGUINS, Geof	Midhurst Research Unit
STROEMPL, George	OTIFBI, Maple
SWAILE, Brian	Tree Seed Plant
TARJAN, David	Thessalon Tree Nursery
TIMMER, Vic	University of Toronto
TODD, Bill	Orono Tree Nursery
WATSON, Stephen	Midhurst Research Unit
WAYWELL, Charlie	Guelph
WHELAN, Brian	Thessalon Tree Nursery
WYNIA, Adolf	St. Williams Tree Nursery